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The Technique and Value of Project Teaching in General Science

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CHAPTER III.

METHOD USED IN CHECKING THE RESULTS OF PROJECT TEACHING IN GENERAL SCIENCE.

1. Working Conditions of Experimental Classes and Co-operating Schools.

In order to determine whether project teaching as described in the two preceding sections secures as good results with students in general science classes as traditional types of teaching, comparison of the results reached by two types of teaching situations is necessary. To make such a comparison valid it is essential to consider the possible effect of factors, other than the type of student activity and the difference in teacher's technique, that are active agents in modifying the results of school work. Such factors are: (1) the personality and training of the teacher, (2) the quantity and kind of laboratory equipment, (3) the text, (4) the library facilities, (5) the age, grade, and relative ability of the students (6) the size of classes, (7) the length and number of class periods, and (8) the amount of outside work required of students.

No one teacher was responsible for the results secured by the project teaching in general science in the University High School. The original class of the spring-summer term of 1920 was taught by Mr. E. A. Muench with the assistance of an inexperienced student teacher. Mr. Muench had just completed his college course with training in several elementary sciences but was not a science specialist. He had taught general science in the University High School during the previous regular session. His assistant was a senior in the School of Education, especially trained for work in chemistry although she had taken elementary courses in several of the special sciences. Measured results for this class do not appear in the tabulations presented

later in this study, but since the work done under the direction of these two teachers furnished the groundwork for the classes which followed they are included in this description.

The 1920-21 class was taught at different times during the fall term by two practice teachers. Both of these teachers were seniors in the School of Education and both were especially trained in biology although they had taken elementary courses in physics and chemistry. Neither had had previous experience in teaching. Both were rated as mediocre teachers and were dissuaded from continuing with the class at the end of the fall term. At the beginning of the winter term this class was taken over by the science supervisor and taught by him for the remainder of the term. Owing to conflicts in the supervisor's schedule the class time for this winter term was reduced from two fifty minute periods per day to one fifty minute period per day.

During the regular session of 1921-1922 the class was taught by Mr. P. G. Buckles, who was science supervisor in the University High School during that year. Mr. Buckles was a man of wide teaching experience. He had been for a number of years superintendent of various schools in the state. He was a graduate of one of the state teachers colleges, and had training in various sciences but was not a specialist in any one field. He had never previously tried project teaching, and had not taught general science.

During the regular session of 1922-23 the experimental class was taught by a practice teacher, a senior in the School of Education, who had had no previous teaching experience. She was better trained in biology, but had taken courses in physics and chemistry.

The results secured during the sessions of 1920-21 and 1921-22 as measured by the general science test[39] tend to show that the teacher was not a major influence in the work done in the University High School, since the results shown were secured over a period of three years with five different teachers.[40]

The laboratory equipment available for the use of the general

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39 For a detailed description of the test and the measurement of classes see section 2 of this chapter and chapter IV.

40 See Table XVI, page 413.

science classes in the University High School was essentially like that to be found in any small high school in the state. There was no special equipment for general science. Apparatus which was originally bought for physics, chemistry, biology, and physical geography classes was all available for use in general science classes. This equipment consisted chiefly of two sets of old apparatus. One was the accumulation of the University High school through a period of fifteen years. During part of this time all of the physical science equipment was in disuse and had deteriorated rapidly. The other set of old apparatus was acquired from a military academy that had been discontinued. The state of repair of this set was much like the other although it contained a few good pieces that were not in the original set. To this old apparatus $500 worth of new apparatus was added during the winter term of 1921. Since then the materials consumed have been replaced and a few new pieces bought but no large additions have been made. The total value of the science equipment in the University High School was in the spring of 1922 about $1000.

The only modifications in equipment made for carrying on project work in general science were in the purchase of a considerable body of raw materials and a work bench and tools. This raw material was secured in order to enable students to manufacture much of their own apparatus, and consisted of such things as wire of various kinds and sizes, sheet metals, asbestos, screws, bolts, nails, lumber, corks, many wide mouth bottles, much glass tubing chemicals, etc. The tools consisted of duplicates of the most frequently used wood working tools, two soldering sets, pliers of various sizes, metal shears, hack saws, and screw drivers. The work bench was equipped with two steel vises. The raw materials were replaced as soon as they were used up.

In the experimental classes no books were used as texts. All the science books in the school library were moved to book shelves in the science room and were constantly available to classes in general science. This library contained most of the commonly used general science texts as well as frequently used texts in botany, zoology, chemistry, physics, geography, physical geography, elementary astronomy, bacteriology, physiology and

hygiene. In addition there were books on birds, wild animals, flowers, weeds, trees and insects. Books of the types of *Harpers Electricity Book for Boys and Keene's Mechanics of the Household* were also included. Altogether there were 200 volumes in this library with an estimated total value of $250. In addition there were many pamphlets and bulletins such as Farmers Bulletins and the publications of the Audubon Society.

The membership of the experimental classes was limited to junior high school students, that is, students in 7th, 8th, and 9th grades. The class of 1920-21 was made up of students in all three grades. The students in this class ranged in age from thirteen to twenty-two. Three students were twenty-two. Two of these were foreign students whose native tongue was Spanish, and whose control of English was very limited. The remainder of the class ranged in age from twelve to seventeen. The class of 1921-22 was almostly wholly a ninth grade class with a range in age from twelve to seventeen. The class of 1922-23 was a 7th and 8th grade class with no 9th grade students. The range in age of this class was from twelve to fifteen.

The relative ability of the students in all of these classes is shown by their scores on the *Terman Group Test of Mental Ability* given in Chapter IV.[41]

These classes were all of normal size. The class of 1920-21 contained twenty-four students, that of 1921-22 twenty-three, and that of 1922-23, twenty-four. In other words, these classes were small enough to insure efficient work, and large enough to demonstrate that whatever worth while results were secured were not due to the smallness of the classes.

All science work in the University High School is conducted on the basis of a double period daily. Any part of these double periods may be used for laboratory work, or, if the nature of the problem demands, for study, conference, or discussion. Class periods are normally fifty minutes in length. These double periods are therefore one hundred minutes in length. All of the experimental classes in general science followed this schedule except the class of 1920-21. This class met for double periods daily during the fall term, but only for fifty minute periods

41 See page 412.

daily during the winter term. The total amount of time spent in class work by this class exceeded, however, the minimum of 280 minutes per week required by the State Department of Education.[43] The total number of minutes required by the State Department would amount in thirty-six weeks to 10,080 minutes. The general science class of 1920-21 spent a total of 12,000 minutes in the class-room during a period of thirty-two weeks.

Neither outside work nor home study was required of students in the general science classes under experiment. No lessons were assigned for preparation outside the class period. Many students voluntarily carried on projects outside of class, but this in no way took on the character of assigned lessons. All reading, study, laboratory work, etc. could be done during the 100 minute period. Work done outside of this period was entirely voluntary. The minimum amount of time given to general science by students was, therefore, 200 clock hours in 1920-21 with a thirty-two week year, and 300 clock hours in 1921-22 and 1922-23 with a thirty-six week year.

The schools from which general science classes were chosen for comparison with the experimental classes were selected at random, chiefly on the basis of availability. Schools were chosen whose superintendents or science teachers were ready and willing to co-operate in the experiment. The schools for the second series (1922-23) were, in addition, selected because of geographical convenience,—the larger schools within a radius of forty miles from Columbia. All were first class fully accredited high schoools, measuring up to the standards established by the State Department of Education. All were members of the North Central Association except schools, A, B, and E in the first series (1920-21).

Since these schools were all first class high schools all general science teachers, except the teacher in school A, where general science was taught in the eighth grade, were required to meet the following standards: "In second and first class high

43 "Course of Study—Missouri High Schools," 1919, p. 66, sec. 2.

schools the minimum requirements in college hours have been placed as follows: .... General Science 17½ hours in Physical and Biological Sciences with a major of not less than 7½ hours in one Science, and not less than 5 hours in each of two others; ...."[44] The general science teachers in all of these schools, except in school A, were college graduates. School A was surveyed in 1920 by the department of school administration of the University of Missouri. The 8th grade teacher, where general science was taught in this school, was unanimously rated by the group of surveyors as the most efficient teacher in the system. In the ten schools there were twelve general science teachers. The range in previous teaching experience was from one to thirteen years. One teacher in school F had only one year's previous experience. The amount of teaching experience of these twelve teachers is shown in Table III.

TABLE III.

TEACHING EXPERIENCE OF TEACHERS IN CO-OPERATING SCHOOLS.

School	Years' Experience of Teachers	School	Years' Experience of Teachers
A	8	G	6
B	5	W	8 and 3
C	6	X	3
E	13	Y	12 and 6
F	1	Z	2

From the data in this table and the statements above it is evident that no difference is to be expected in results because of the training and experience of the teachers carrying on the two types of work. With five different teachers conducting the experimental work during a period of three years it seems unlikely that any individual teacher's personality was a very large factor in determining the results. This factor would seem also to be minimized in the results obtained from the traditional work where twelve different teachers in ten different schools were involved.

44 "Course of Study—Missouri High Schools," 1919, p. 66, sec. 2.

The condition of the ten co-operating schools with respect to science equipment was quite similar to that of the University High School. In only two of the schools was any general science equipment listed in the report of the state high school inspector for 1920-21. In school X, $50 worth of general science equipment was listed, and in school Z, $150 worth. In all of these schools, however, all of the science equipment, including agricultural equipment, was available for general science classes. Table IV shows the value of laboratory equipment in all of the schools.

TABLE IV.

VALUE OF LABORATORY EQUIPMENT IN CO-OPERATING SCHOOLS.

School	Value of Science Equipment	Value of Science and Agricultural Equipment
A	$ 350.00	$ 725.00
B	1,375.00	1,875.00
C	1,415.00	1,690.00
E	200.00	285.00
F	550.00	850.00
G	1,260.00	1,477.00
W	1,775.00	1,925.00
X	1,050.00	1,150.00
Y	1,478.00	1,653.00
Z	1,400.00	2,300.00
U. H. S.	1,000.00	1,000.00

Only one of these schools, E, is noticeably lacking in equipment. Most of them have more valuable equipment than the University High School.

In all of the co-operating high schools text-books were used. Some variations in results in these schools may be due to the use of texts of varying value. However, no text was used in the experimental classes, and any advantages growing out of the use of a text lie wholly on the side of the schools doing the traditional type of work.

In the matter of library facilities the classes in the University High School had a decided advantage. The use of reference books, is, however, inherent in the system used by the experimental classes and any peculiar advantage growing out of the additional library facilities should be incorporated in the

final results and not separable from them. Following is a comparison of the library facilities in science of the schools investigated:

TABLE V.

LIBRARY FACILITIES IN SCIENCE OF CO-OPERATING SCHOOLS.

School	Number of Science Books in Library	Value	Number of Agriculture Books	Value
A	40	$35.00	175	$180.00
B	?	?	60	90.00
C	70	90.00	35	32.00
E	80	80.00	20	40.00
F	150	100.00	150	225.00
G	50	68.00	46	60.00
W	200	185.00	100	100.00
X	90	80.00	90	90.00
Y	171	100.00	40	50.00
Z	100	125.00	200	125.00
U. H. S.	200	250.00		

The students in the ten co-operating schools were with few exceptions 9th grade students. There was one general exception to this rule. All the students in general science class in school A were in the 8th grade. The age range for all schools was normal for the grade. The relative mental ability of the students in all the co-operating schools in shown in the tabulations in chapter IV. As a whole the students doing the traditional type of work were more mature than the students in the experimental classes. In every case the median intelligence scores for the classes in the University High School were lower than those of the classes in the co-operating schools.[45]

The general science classes in the schools used for comparison ranged in size from one of fifteen in school Y to one of thirty in school Z. No classes contained more than thirty students and all were, therefore within the limits set by the State Department of Education.

All of the high schools doing the traditional type of work followed the typical science schedule of three single recitation periods per week and two double laboratory periods per week. The minimum length of the class period was forty minutes.

45 Page 411.

With the forty minute period this schedule reached the minimum of 280 minutes per week established by the State Department. In school A where general science was taught in the 8th grade one forty minute period daily was devoted to class work with irregular laboratory work at other times. In all of the schools most of the recitation periods were taken up in reciting upon the text-book material. The double laboratory periods were used either for individual laboratory work or for demonstration by the teacher. In all schools outside preparation of lessons was required. Assuming one hour per day as a minimum of preparation for high school students the time spent on general science per week in the co-operating schools would amount to nine and two thirds hours as compared to a minimum of eight and one third hours per week for students in the University High School. Table VII shows the minimum amounts of time spent on general science in the co-operating schools.

Data concerning the conditions in the co-operating schools were secured from direct observation and interviews with the general science teachers, from a questionnaire sent to all the general science teachers and from the reports of the state high school inspector filed in the Registrar's office at the University of Missouri.

TABLE VI.

AMOUNT OF TIME SPENT IN GENERAL SCIENCE WORK IN CO-OPERATING SCHOOLS.

School	Length of class period minutes	Number of laboratory periods per week	Total time in classroom per week in min.	Amount of preparation required per day in min.	Total min. time spent on gen. sci. per week
A	40	irreg.	200+	60	500+
B	40	2	280	60	580
C	45	2	315	60	615
E	40	2	280	45	505
F	40	2	280	60	580
G	45	2	315	60	615
W	40	2	280	60	580
X	45	2	315	60	615
Y	45	2	315	60	615
Z	40	2	280	60	580
U. H. S.	100	varying	500	0	500

From the preceding summary of the factors influencing the work done in both the University High School and in the co-operating schools it seems that the conditions surrounding the classes doing the two types of work are sufficiently similar to make a valid comparison of the results of the two kinds of school activity under consideration if the means of measurement devised is at all sound.

2. MEANS OF MEASURING RESULTS.

To get at the value of project teaching a comparisen was made of the work of the classes selected for experiment with that of similar classes in other schools where the traditional type of activitiy was carried on. To make this comparison it was necessary to devise some means of measuring the results secured by the two types of school activity. At the time the experimental work was begun in the University High School no usable general science test had been published. It was, therefore, necessary to invent some such device in order to carry out this study. Accordingly in the fall of 1920 the test given on pages 68-72 was constructed.

In order to be fair to schools using various text-books the content of the test was determined by a topical analysis of eight commonly used general science text-books. Only those topics were included in the test that were common to seven out of eight of these books. Within the ranges of these topics the selection of the material for the test was purely arbitrary.

The folowing texts were used in this analysis: Barber, F. D. et al., *First Course in General Science*; Caldwell, O. W. and Eikenberry, W. L., *General Science*; Clark, Bertha, *An Introduction to Science*; Hodgdon, D. R., *Elementary General Science*; Smith, W. P. and Jewett, E. G., *Introduction to the Study of Science*; Trafton, G. H., *Science of the Home and Community*; Van Buskirk, E. F. and Smith, E. L., *The Science of Everyday Life*; Snyder, W. H., *Everyday Science.* These books were selected because of availability, common use, and comparative recency of publication. The dates of publication range from 1915 to 1920. The table of contents of Trafton's *Science of the Home and Community* was used as the original basis of classification with some slight modifications in termin-

ology to reconcile titles with those of other books in which obviously the same materials were treated. The topics from the other books were added as the tabulation progressed. If the topics in the category used did not appear in the table of contents of a particular book the index was used to determine whether or not the topics were treated. If similar material was found to be presented as a separate topic it was included in the tabulation following the title of the books under consideration. Finally the whole series of texts was reviewed by scanning every topic treated, using the topic headings as guides.

Fifty-six large topics were presented by some or all of these eight texts. Of these fifty-six large topics twelve were found to be common to at least seven out of the eight texts analyzed. These twelve topics are: heating the home, ventilating the home, lighting the home, water supply and the properties of water, foods and diet, household appliances, electricity and magnetism, disease prevention, weather and its prediction, micro-organisms, simple machines, air and its properties. All of the questions and exercises of the general science test, except number twenty-six, deal with subject-matter included within these twelve topics. Number twenty-six was designed to determine acquaintance with the names of foremost scientists. This question was included on the assumption that students who were reasonably familiar with the subject-matter of science should be familiar with the names of the great workers in the field.

After the test was constructed on the basis just described an analysis was made to determine to what extent it measures results in terms of commonly accepted general science aims. This analysis shows that the test measures results chiefly in terms of the two general aims, the acquisition of a fund of information about nature and science (aim C) and the securing of an understanding and control of everyday environment (aim D), upon which general science teachers are in fair agreement as is shown in Chapter I, section 4.

The following analysis of the test by questions will show to what extent it measures results in terms of the two aims:

Table VII.

Comparison of Questions in General Science Test with Aims for Teaching General Science.

Question Number	Aim Measured[46]	Question Number	Aim Measured[46]
1	C	14	C and D
2	C	15	C and D
3	C and D	16	C and D
4	D	17	D
5		18	C and D
6	D	19	C
7	D	20	C
8	D	21	C
9	C and D	22	C and D
10	C and D	23	C and D
11	C and D	24	C
12	C and D	25	C and D
13	C and D	26	C

From this tabulation it will be observed that twenty out of twenty-seven questions measure results in terms of aim, C, and that eighteen out of twenty-seven measure results in terms of aim, D. Thirteen, or approximately 50%, of all the questions measure both aims. Only two questions, numbers five and twenty-seven, measure neither of these two aims. Number five tests ability to use a general science index, and number twenty-seven ability to read general science subject matter.

It is obvious that the test is also in some degree a measure of other factors. Problem solving and reflective thinking are required in working out answers to some of the questions, for example, numbers 2, 4, 10, and 23. Some questions partially test ability to do laboratory and experimental work, e. g., numbers 2, 3, 10, 22, and 23.

Additional evidence concerning the validity of the test is furnished by a comparison of the subject-matter with the study of C. M. Howe.[47] Howe included in his questionnaire to general science teachers a long list of topics which might possibly be included in a course in general science. He asked that each teacher mark "F" those topics considered as fundamental, and "S" those considered as valuable supplementary topics.

46 C and D are used here to refer to the two aims in order to be consistent with the key on page 253.

47 See pages 254-255.

Eighty teachers replied to this questionnaire. The topics were ranked according to the number of times each was marked as fundamental. Twenty-two topics were marked as fundamental by more than 50% of the teachers replying. In Table VIII are shown these twenty-two fundamental topics, and opposite each the numbers of the questions in the general science test dealing with that topic.

TABLE VIII.

COMPARISON OF THE GENERAL SCIENCE TEST WITH HOWE'S "FUNDAMENTAL TOPICS."

	Topic	Frequency from Howe's Questionnaire	Test Questions
1.	Water, physical properties, mechanics of liquids	73	9, 10
2.	Air, chemical composition and combustion	71	1, 3
3.	Air, physical properties and mechanics of gases	69	3, 4, 20
4.	Ventilation	63	3, 4, 5
5.	Household heat and light	62	6, 7, 8, 9
6.	Water supply and purification	60	11, 12
7.	Weather and climate	59	19, 20
8.	Bacteria, yeasts and molds	58	16, 17, 18
9.	Foods, diet and digestion	57	13, 14, 15, 27
10.	Combustion and fuels	56	1
11.	Hygiene and sanitation	55	2, 4, 6, 8, 16, 17, 18
12.	Water, chemical properties	55	11, 12
13.	Plant life, elementary biology	50	
14.	Everyday chemistry	49	1, 2, 11, 12
15.	Simple machines	48	21, 22
16.	Force, power, energy	47	
17.	Animal life, elementary zoology	46	
18.	Systems of measurement	43	
19.	Acids, bases and salts	43	
20.	Elements, compounds, mixtures	42	1, 12
21.	Density, specific gravity, buoyancy	42	9, 20
22.	Electricity and magnetism	41	23, 24, 25

According to this table all but five of Howe's "fundamental topics" are covered by questions or exercises in the general science test. Sixteen are covered by more than one. In addition the "fundamental topics" having the greatest frequency, the first twelve, receive the greatest emphasis in the test.

From the three sets of evidence presented it seems that the test used is a fair measure in so far as the actual subject-matter

content and the current aims of general science courses are concerned.

To get a further idea of the validity of the test, correlations were made between the teacher's rating and the scores on the general science test for students in the general science class in the University High School for 1921-22 and for the students in the general science classes in schools C, E, F, and G. In the University High School the teacher's ratings were made before the test was given. In the other schools the ratings were made before the test scores were reported to the teachers. The Pearson product-moment formula was used in calculating all correlations.

Correlations were found to be as follows: U. H. S. 1921-22, 0.72; school C, 0.56; school E, 0.39; school F, 0.75; school G, 0.56. The probable errors were, in corresponding order, 0.07, 0.07, 0.06, 0.06, 0.07.

Taken together these five correlations show a substantial correlation between scores on the general science test and teacher's grades in general science. McCall says that "when r is 0 to $\pm.4$ correlation is low, or $\pm.4$ to $\pm.7$ correlation is substantial, or $\pm.7$ to ±1.0 correlation is high."[48] Assuming the validity of teachers' grades it seems, therefore, safe to assume that the test is a fairly reliable measure of students' control of general science subject-matter.

In order to determine the reliability of the test it was given to two groups of thirty-seven and thirty-eight high school students who were not included in the study of results, and who had not taken the test previously. After intervals of one and two weeks the test was repeated with the same group of students. The correlations between these two sets of scores were then determined. These correlations were found to be 0.62 and 0.62.[49] This indicates that the test is in some degree a measure of a student's general science information,—at least that his response to it is not merely a matter of chance.

The relative weighting of the various exercises and questions

48 McCall, W. A., "How to Measure," pp. 392, 393.

49 McCall says, on p. 396 of "How to Measure," ".......... the range of self-correlation for most standard tests is about .5 to about .9 ...."

in the test was entirely arbitrary. No attempt was made to assign values on the basis of relative difficulty. Neither did relative worth greatly influence the assigning of scores. Convenience in scoring had more influence than any other single factor. Originally a value of ten was given to all questions. Later, to make the number of incorrect answers balance the number of right answers, numerous changes were made. In general a value of two was assigned to the sub-parts of questions, but there are exceptions where this value would greatly increase or decrease the total value of a particular question.

In general the position taken by the writer in regard to weighting is that the test was used for the purpose of comparing classes, and therefore the weighting of individual questions made little difference so long as the test as a whole and the arbitrary values assigned to questions remained constant throughout the experiment. It will be observed that the test can be scored quite mechanically and that the judgment of the scorer is practically eliminated. As long as this is true the test may serve as a means of comparing different types of work.

The test as it was used in this study is shown on the following pages.

GENERAL SCIENCE TEST.

NAME..........................AGE......GRADE IN SCHOOL...... GIRL / BOY

SCHOOL..................... CITY.................. DATE..........

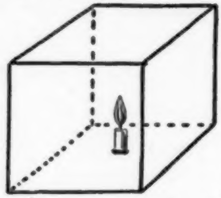
1. Check (x) in the following list the substance in the air that is necessary for burning.

Carbon Dioxide	Oxygen	Argon
Nitrogen	Hydrogen	Water vapor

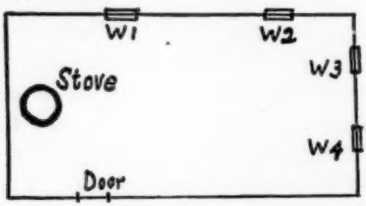
2. Check (x) in the following list of equipment the material necessary to perform an experiment to prove that carbon dioxide is given off in breathing.

3 ft. of glass tubing	1 short piece of glass tubing
1 bunsen burner	8 oz. marble chips
1 wide-mouth bottle	1 small beaker
1 2-hole rubber stopper	2 oz. hydrochloric acid
2 tablespoons of lime water	

3. Below is a diagram of a closed box containing a candle. Where would you make openings to keep the candle burning? Indicate the places for openings by making circles in the diagram.



4. Below is the floor plan of a room heated by a stove. How would you regulate the windows to secure good ventilation? Describe the windows by number.



5. Check (x) in the following list the words that you would look for in the index of a General Science book in order to get help in solving a ventilation problem.

Yeast	Oxygen	Bunsen Burner
Water Vapor	Lungs	Furnace
Ventilation	Humidity	Electricity
Temperature	House Heating	Eclipse
Photography	Heat	Dust
Nitrogen	Germs	Cyclone
Air	Antiseptic	Calorie
Airplane	Bacteria	Caustic
Alcohol	Balloons	Carbon dioxide
Alimentary Canal	Breathing	Convection

6. Check (x) in the following list the fact that will make the sentence true.

In reading the light on the book should come from—

Directly in front	Over the right shoulder
Directly behind	The right
Over the left shoulder	The left

7. Check (x) in the following list the type of lamp that will make the most light at the lowest cost.

Carbon filament lamp.
Tungsten lamp
Nitrogen filled lamp

8. Check (x) in the following list the colors that make good colors for lamp shades.

Blue	Green	Pink
Red	Yellow	Orange

9. Check (x) the facts in the following group that will make the sentence true.

The water in a hot-water tank circulates in the tank because—

Hot water expands when heated.
Hot water is lighter than cold.
The steam pushes the water up.
The water is pushed up by air pressure.

10. Check (x) in the following list of equipment the materials that you would need to set up and operate a siphon.

2 ft. of glass tubing	2 battery jars
1 air pump	1 file
3 ft. of rubber tubing	1 Bunsen burner
3 2-hole hubber stoppers	1 wide-mouth bottle

11. Check (x) the facts in the following group that will make the statements true.

Hard water is caused by—

Organic matter in the water.
Soot from the roof.
Lime and magnesia in the water.
Rust from the pump.

12. Check (x) in the following list the substances that may be used to soften hard water.

Lime	Charchoal	Washing soda
Soap	Ammonia	Lye
Sulphur	Blueing	

13. Check (x) the foods in the following list that are largely starch.

Potatoes	Lettuce	White of egg
Crackers	Bread	Cheese

14. Check (x) the foods in the following list that will help the body most in building tissue.

Potatoes	Milk	Cheese
Lean meat	Eggs	Butter
Candy	Green beans	

15. Check (x) the foods in the following list that will make fat.

Candy	Oranges	Butter
Sugar	Spinach	Green beans

16. Check (x) in the following list the things that will check the growth of bacteria.

Boiling	Sulphur
Sunlight	Carbolic acid solution
Darkness	High oven temperature
Room temperature	Turpentine
Water	Alcohol

17. If a typhoid fever epidemic should break out in your community, how could you make the water safe to drink in your home?

18. Check (x) in the following list the places where bacteria are apt to grow rapidly.

Milk bottles left without washing	Clothing that has been ironed
Crowded picture shows	Finger tips
Specimens in alcohol	Dark rooms
Dishes that are scalded	Clean sunny rooms

19. Check (x) in the following list the facts that would help in predicting the weather.

    The barometric pressure at all weather stations.
    The direction of the wind.
    The condition of the fur of wild animals.
    The phase of the moon.
    The location of mountain ranges.
    The prediction of the last almanac.

20. Check (x) in the following list all the facts that will make the sentence true.

    A low barometer is caused by—
    Increased atmospheric pressure.
    An increase in the amount of water in the air.
    Low altitude.
    High altitude.
    A decrease in the amount of water vapor in the air.
    Decreased atmospheric pressure.

21. Check (x) in the following list the machines that depend upon levers for their efficiency.

Block and tackle	Pump handle	Stairway
Typewriter	Wagon wheel	Scissors
Tack lifter	Screw	

22. Check (x) in the following list of equipment the materials needed to find out mechanical advantages of a block and tackle.

1 vernier calipers	1 platform balance
1 yard stick	1 block with 2 pulleys
1 block with 3 pulleys	1 set of weights
1 ball of twine	1 board 3 ft. x 6 in.

23. Check (x) in the following list of equipment the materials necessary for making an electro-magnet.

1 bar magnet	1 bell armature
30 ft. No. 30 insulated copper wire	2 ft. glass tubing
1 pair pliers	1 meter stick
1 soldering set	1 Bunsen burner
1 iron bolt ¼x2½ in.	1 file

24. Fill in the blanks in the following sentence so that the meaning will be complete and the sentence true.

    When a coil of wire is................in................field, an........................current is produced. When an ....is sent through a coil of wire suspended in a........................field, the coil will turn.

25. Check (x) in the following list the statements that will make the sentence true.

To make an electric grill that will heat quickly—

Small wire should be used.
Large wire should be used.
A short length of wire should be used.
A long strip of wire should be used.
Copper wire should be used.
Nickel-chrome steel wire should be used.

26. Check (x) in the following list the names of the great scientists.

Kant	Washington	Newton	Pasteur
Galileo	Rumford	Darwin	Curie
Gladstone	Boone	Clemenceau	Irving
Mendel	Einstein	Archimedes	Ohm
Longfellow	Emerson	Webster	Socrates

27. Read this paragraph and then write the answers to the questions below. Read the paragraph again if necessary.

"The number of calories required during a day by a person depends upon weight, activity, and age. The larger a person, the more food he needs, if weight is due to tissue and not to excessive fat. The number of calories depends very largely on the activity of the person. It increases rapidly as the work becomes more severe. Exercise is often classified into four groups: light, moderate, active, and severe. Men of sedentary occupations, such as teachers and bookkeepers, take light exercise; mail carriers and carpenters, moderate exercise; soldiers and lumbermen, severe exercise. Women usually require fewer calories than men because they weigh less and perform less vigorous work."

1. What is the relation between size and food requirement?
   ....
2. Upon what does the number of calories that an individual needs depend? ....
3. Into what four groups is exercise usually classified?
   ....
4. Why do women require fewer calories than men?
   ....
5. What classes of people engage in sedentary occupations?
   ....
6. Write *Yes* in the margin before each of the following statements that are true, according to the paragraph above. Write *No* before those that are not true.
   Men require fewer calories than women.
   Soldiers and lumbermen take severe exercise.
   The number of calories needed depends largely upon muscular activity.
   The number of calories needed does not change with age.

The objectivity of the test may be judged by the following directions for administering and scoring:

DIRECTIONS FOR GIVING GENERAL SCIENCE TEST.

Read to Students:

Do not turn these papers over until you are told to do so. When I say "Begin," turn over the papers and fill in the blanks at the top of the page, telling your name, age, grade, name of your school, name of the town in which you live, the date, and whether you are a boy or girl. Do nothing else until I say "Go."

This test is to see how much you know about general science. Your score will not affect your grade. Do your best, however, so that your school will show up well in comparison with other schools in the state. Be sure that you do not see your neighbor's work.

Do exactly what the directions at the beginning of each exercise tell you to do. Where questions are asked, write the answer below the question. Go straight through the test. You will have the whole class period to finish if necessary.

When I say "Stop," everyone must stop.

To the Teacher:

Distribute papers face down. See that each student is provided with a pencil.

Repeat the first paragraph of the instructions above if necessary.

One class period of forty minutes should provide for sufficient time for everyone to finish the test. Allow students as much time as they need within this limit.

Answer the questions of students about what to do, e. g., check in left-hand margin, write out the answer, fill in the blank spaces, etc. *Give no hints as to answers to questions.*

Please check (x) on the attached sheet the books that you have in your library that are available for students in general science.

Return all copies ot the test, unused as well as used. It is important that every test sent out be returned.

Sample copies of the test for teachers and superintendents will be furnished gladly when the entire experiment is finished.

The method of scoring the test, together with the maximum number of points for each exercise, is shown in detail in the following instruction sheet:

DIRECTIONS FOR SCORING GENERAL SCIENCE TEST.

The maximum score is 247.

Any clear method of indicating the answer will be accepted.

Exercise	Method of Scoring	Possible Value
1.	Score right or wrong	10 or 0
2.	Score right or wrong	10 or 0
3.	Score right or wrong	10 or 0

4.	Score right or wrong	10 or 0
5.	1 for each correct, —1 for incorrect..........	15 to —15
6.	Score right or wrong	10 or 0
7.	Score right or wrong	10 or 0
8.	2 for each correct, —2 for incorrect...	6, 4, 2, 0 —2, —4, —6
9.	4 for each correct, —4 for incorrect..........	8, 4, 0, —8, —4
10.	Score right or wrong	10 or 0
11.	Score right or wrong	10 or 0
12.	2 for each correct, —2 for incorrect........	8, 6, 4, 2, 0, —8, —6, —4, —2
13.	2 for each correct, —2 for incorrect........	6, 4, 2, 0, —2, —4, —6
14.	2 for each correct, —2 for incorrect........	8, 6, 4, 2, 0, —2, —4, —6, —8
15.	2 for each correct, —2 for incorrect........	6, 4, 2, 0, —2, —4, —6,
16.	2 for each correct, —2 for incorrect......	10, 8, 6, 4, 2, 0, —2, —4, —6, —8, —10
17.	Score right or wrong	10 or 0
18.	2 for each correct, —2 for incorrect........	8, 6, 4, 2, 0, —2, —4, —6, —8
19.	2 for each correct, —2 for incorrect........	6, 4, 2, 0, —2, —4, —6
20.	2 for each correct, —2 for incorrect........	6, 4, 2, 0, —2, —4, —6
21.	Score right or wrong	10 or 0
22.	Score right or wrong	10 or 0
23.	Score right or wrong	10 or 0
24.	2 for each blank correctly filled, "electric current" counted as one word..............	10, 8, 6, 4, 2, 0
25.	2 for each correct, —2 for incorrect........	6, 4, 2, 0, —2, —4, —6
26.	1 for each correct, —1 for incorrect........	10 to —10
27.	3 for each correct answer, 1 or 2 for partly correct answers	18 to 0

A key was used in all scoring, and papers were marked according to the key rather than according to the scorer's judgment.

CHAPTER IV

COMPARATIVE RESULTS OF PROJECT TEACHING AND THE TRADITIONAL TYPE OF TEACHING IN GENERAL SCIENCE.

The general science test described in the preceding section was given to the general science class in the University High School in the fall of 1920 and again in the spring of 1921. In the spring of the same year it was given to the classes in two other schools, A and J. During the school year of 1921-22 the test was given to the general science classes in the University High School, and to the classes in eight co-operating schools. The *Terman Group Test of Mental Ability.* Form A, was also given to all of these classes except to those in school J. The data for this school are therefore not used in this study, Tests in 1921-22 were given in the fall and spring in the experimental class and in schools B, C, D, and H. In the other four schools only the spring test was given, since it was not possible to engage their co-operation early enough to secure fall scores. Later, the data for schools D and H were discarded becouse of the smallness of the classes. The tests in the University High School and in school A in 1920-21 were given by a trained investigator. All tests given during the school year of 1921-22 were given by the science teachers in the various schools. The directions followed by these teachers are given on pages 73 in the preceding section.

Since it was found necessary to discard the data for schools D and H, the data showing *comparative growth* of the students carrying on the two types of work were considered insufficient. Therefore, to supplement the data secured during the school years of 1920-21 and 1921-22 a new set of tests was given in 1922-23 to the class in the University High School and to fourteen classes in schools W, X, Y, and Z, a total of 368 students. Two general science tests were given to all of these classes, one during the last two weeks in September, and a second during

the last two weeks of January. All of these tests were given by a single trained investigator. The *Terman Group Test of Mental Ability*, Form A, was also given to these classes.

Table IX[50] presents a summary of the median spring scores for the schools tested during 1920-21 and 1921-22. The fifth column in the table gives a group achievement ratio, which is obtained by dividing the median general scicnce score for each class by the median intelligence score for the same class. This is not a scientific achievment quotient such as is used for comparing individuals, but a simple means of comparing the work of several classes with varying intelligence.

Table X[51] shows the comparative growth of four classes, in two of which project teaching was carried on, and in two traditional text-recitation-laboratory work, The mean growth in column five is secured by subtracting the scores of each individual for the fall test from the corresponding scores for the spring test and finding the arithmetical mean of these differences. The growth for the school year is computed by dividing the mean growth (column five) by the time between tests, in months, and multiplying by nine. This procedure assumes that growth was uniform throughout the year. Although the validity of this assumption may be questioned, it is at least as valid for one school as for another since all were treated alike. A growth ratio for the group is presented in column eight. This ratio is secured by dividing the mean year's growth for each class by the mean intelligence score of the class.

The use of this growth ratio is based on the assumption that a high intelligence score is indicative of ability which should enable the student to secure general science information more readily and therefore make a high score on the general science test; and that regardless of the relation of intelligence scores to chronological ages a high intelligence score should, in general, indicate ability to make a high general science score. This assumption is supported by the following correlations between

50 Page 411.
51 Page 411.

the intelligence scores and the fall general science scores of the students in seven classes elected at random from those tested:

Class		P. E.
W, I	.40	.12
W, II	.57	.10
X, I	.51	.10
X, IV	.66	.08
Y, II	.84	.05
Z, II	.51	.10
U. H. S. 1921-22	.72	.08

Table XI[52] presents a summary of the comparative growths in general science of the fourteen classes in schools W, X, Y, and Z, and the three experimental classes in the University High School. The same method of tabulation and computation that is used in Table X, page 411, is used for this table.

Table XII[53] presents a summary of the growth ratios of all classes for which growth ratios were secured. This table is a summary of Tables X and XI.

Table XIII,[54] shows a comparison of the mean growth ratio for all co-operating schools, where such a ratio could be secured, with a mean growth for the three experimental classes. This mean growth ratio, or combined growth ratio, was secured for each contrasting group of schools as follows: (1) The total growth for each class was divided by the number of months between general science tests and this quotient multiplied by nine to get the total growth for the school year for that class. (2) The total year's growths for all classes were added. (3) The total number of students was found by adding the number of students in each class. (4) The sum of the year's growths for all classes was divided by the total number of students to get a mean year's growth. (5) The sum of the intelligence scores for all students was found. (6) The total of the intelligence scores was divided by the number of students to get a mean intelligence score. (7) The mean year's growth was divided by the mean intelligence score to get the mean growth ratio.

52 Page 412.
53 Page 412.
54 Page 413.

Table XIV,[55] presents a comparison of the mean growth ratio for all classes in the co-operating schools tested in 1922-23 with the mean growth ratio for the three experimental classes.

Table XV,[56] gives a comparison of the mean growth ratio for the three best co-operating classes with the mean growth ratio for the three experimental classes.

Table XVI shows a comparison of the mean growth ratio of the four classes in school X, where the best text-recitation-laboratory work was done, with the mean growth ratio of the three experimental classes. The four classes in school X were all taught by the same teacher during the same school year. The three experimental classes were taught at different times by five different teachers and were carried on for three consecutive years.

TABLE IX.

COMPARISON OF SPRING SCORES IN GENERAL SCIENCE OF SIX CO-OPERATING SCHOOLS AND '21 AND '22 CLASSES IN U. H. S.

School	Date of Test	Median G. S. Score	Median Int. Score	Achievement Ratio	No. of Pupils
A	Mar. 17, 1921	72	99	73	16
B	May 10, 1922	79	113.5	70	36
C	May 12, 1922	82.5	89.5	92	46
E	May 1, 1922	76	92	83	52
F	May 6, 1922	100	110	91	25
G	May 4, 1922	112	113	99	45
U. H. S.	Apr. 15, 1921	101	59	171	17
U. H. S.	May 8, 1922	96	70	137	22

TABLE X.

COMPARATIVE GROWTH AS MEASURED BY THE GENERAL SCIENCE TEST IN SCHOOLS DOING TWO TYPES OF WORK, U. H. S. 1920-21 AND 1921-22 AND B AND C, 1921-22.

School	Date Fall Test	Date Spring Test	Time in Months	Mean Growth	Year's Growth	Mean Int. Score	Growth Ratio
B	Dec. 1	May 10	5	1	2	113	0.1
C	Nov. 18	May 12	5.5	16	26	91	29
U. H. S.	Dec. 15	Apr. 15	4	33.6	75.6	61	123
U. H. S.	Oct. 5	May 8	7	43	55	76	73

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56 Page 413.

TABLE XI.

COMPARATIVE GROWTH AS MEASURED BY THE GENERAL SCIENCE TEST IN SCHOOLS DOING TWO TYPES OF WORK, U. H. S., 1920-21, 1921-22, 1922-23, AND SCHOOLS W, X, Y AND Z, 1922-23.

School	Date G. S. Test I	Date G. S. Test II	Time in Months	Mean Growth	Year's Growth	Mean Int. Score	Growth Ratio
U. H. S. 1920-21	Dec. 15	Apr. 15	4	33.6	75.6	61	123
X, I	Sept. 25	Jan. 25	4	46	103	105	98
U. H. S. 1921-22	Oct. 5	May 8	7	43	55	76	73
X, IV	Sept. 25	Jan. 25	4	32	72	98	73
U. H. S. 1922-23	Sept. 21	Jan. 26	4	17	39	54	72
X, III	Sept. 25	Jan. 25	4	36	81	121	67
W, III	Sept. 15	Jan. 11	4	19	43	78	55
X, II	Sept. 25	Jan. 25	4	28	63	117	53
W, I	Sept. 15	Jan. 11	4	24	54	105	51
Y, II	Sept. 27	Jan. 16	3.5	14	36	76	47
Y, I	Sept. 27	Jan. 16	3.5	16.6	40	90	44
W, II	Sept. 15	Jan. 11	4	17	38	87	44
Y. III	Sept. 27	Jan. 16	3.5	13	36	81	44
Z, III	Sept. 29	Jan. 23	4	16	36	100	36
W, IV	Sept. 15	Jan. 11	4	17	38	114	33
Z, I	Sept. 29	Jan. 23	4	12	27	101	27
Z, II	Sept. 29	Jan. 23	4	9	20	97	21

TABLE XII.

COMPARISON OF GROWTH RATIOS FOR ALL SCHOOLS IN WHICH GROWTH RATIOS WERE SECURED.[57]

School		Growth Ratio	School		Growth Ratio
U. H. S.	1920-21	123	Y, I	1922-23	44
X, I	1922-23	98	W, II	1922-23	44
U. H. S.	1921-22	73	Y, III	1922-23	44
X, IV	1922-23	73	Z, III	1922-23	36
U. H. S.	1922-23	72	W, IV	1922-23	33
X, III	1922-23	67	C	1921-22	29
W, III	1922-23	55	Z, I	1922-23	27
X, II	1922-23	53	Z, II	1922-23	21
W, I	1922-23	51	B	1921-22	0
Y, II	1922-23	47			

57 A summary of Tables X and XI.

TABLE XIII.

COMPARISON OF MEAN GROWTH RATIO FOR ALL CLASSES IN SCHOOLS B, C, W, X, Y, Z, WITH A MEAN GROWTH RATIO FOR ALL UNIVERSITY HIGH SCHOOL CLASSES.[58]

Schools	Mean Year's Growth	Mean Int.	Growth Ratio
B, C, W, X, Y, Z	42	99	42
U. H. S. 1920-21, 1921-22, 1922-23	57	64	89

TABLE XIV.

COMPARISON OF MEAN GROWTH RATIO FOR ALL CLASSES IN SCHOOLS W, X, Y, Z, WITH MEAN GROWTH RATIO FOR ALL UNIVERSITY HIGH SCHOOL CLASSES.[59]

Schools	Mean Year's Growth	Mean Int.	Growth Ratio
W, X, Y, Z	47	92	51
U. H. S. 1920-21, 1921-22, 1922-23	57	64	89

TABLE XV.

COMPARISON OF MEAN GROWTH RATIO OF THREE HIGHEST CO-OPERATING CLASSES WITH MEAN GROWTH RATIO OF THE THREE UNIVERSITY HIGH SCHOOL CLASSES.[60]

Classes	Mean Year's Growth	Mean Int.	Growth Ratio
W, I; X, IV; X, III	84	109	77
U. H. S. 1920-21, 1921-22, 1922-23	57	64	89

TABLE XVI.

COMPARISON OF MEAN GROWTH RATIO OF FOUR CLASSES IN SCHOOL X, TAUGHT BY ONE TEACHER, WITH MEAN GROWTH RATIO OF THREE UNIVERSITY HIGH SCHOOL CLASSES TAUGHT BY FIVE DIFFERENT TEACHERS.[60]

Classes	Mean Year's Growth	Mean Int.	Growth Ratio
X, I, II, III, IV, 1922-23	80	111	72
U. H. S. 1920-21, 1921-22, 1922-23	57	64	89

58 A summary of Table XII.
59 A summary of Table XI.
60 Cf. Table XII.

CHAPTER V

CONCLUSIONS.

The conclusions concerning the value of project-teaching are of two kinds: (1) conclusions based upon definite and concrete comparative data secured by measuring, with the general science tests, the results of project teaching in the University High School over a period of three years and the results of text-recitation-laboratory work in ten co-operating schools; (2) conclusions based upon a comparison of the work described in Chapter II of this study with certain principles that are believed to be educationally sound. The first set of conclusions is based upon data in the preceding chapter. Certain of the other conclusions are supported by personal observation, by the statements of Mr. P. G. Buckles, who taught the experimental class in 1921-22, and by the observations of Mr. G. W. Hustead, a graduate student in education who followed the experimental work quite closely during the winter term of 1922. Most of these conclusions support the claims of the advocates of project teaching presented in Chapter I, section three. They are presented as a separate group of conclusions because in the present stage of progress of educational measurements it seems impossible to secure concrete measures of the factors with which they deal. They differ, however, from the usual claims for project teaching[61] that are almost wholly based upon abstract reasoning from definitions and theoretical principles in that they are based upon concrete experience secured during three years of experimenting under actual teaching conditions, and in that they are substantiated by a list of projects actually used and by a definite teacher's technique employed in carrying out these projects.

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61 Cf. pp. 246-248.

CONCLUSIONS BASED UPON DEFINITE AND CONCRETE COMPARATIVE DATA:

Students engaged in project work do as well in reaching commonly accepted aims of general science,—as measured by the general science test used in the study,—as students engaged in the traditional text-recitation-laboratory work.[62]

Taking intelligence into account, students engaged in project work "grow" more in general science,—as measured by the general science test,—than students doing the traditional text-recitation-laboratory work.[63] (Growth here is interpreted as gain in terms of the two commonly accepted aims for general science teaching from a given time at the beginning of the school year to a given time near the end of the school year.)[64]

Regardless of comparative intelligence, classes in which project teaching is used "grow" more on the average in general science—as measured by the general science test,—than the average of classes in which text-recitation-laboratory teaching is used.[65]

Measured by the standards set up, established, and commonly accepted by the schools engaged in text-recitation-laboratory work[66] classes of students carrying on project work do as well as, or better than, students actually engaged in such text-recitation-laboratory work.[67]

For a school year and for classes taken as a whole, the particular projects carried out by any individual student have little effect upon the results attained in terms of commonly accepted standards since students carrying on miscellaneous groups of projects secure as much information as those following logically or "psychologically" organized text-books.[68]

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62 See Tables IX and XVI.

63 See Tables IX-XVI.

64 See analysis of aims of teaching general science, page 256 and preceding, and comparison of general science test with these aims, page 398.

65 See Tables XIII and XIV, column one.

66 See pages 251-256.

67 See Tables IX-XVI.

68 See statement concerning the organization of project work in the University High School, page 335, and comparative results in tables enumerated above.

CONCLUSIONS BASED UPON A COMPARISON OF WORK DESCRIBED IN CHAPTER II WITH PRINCIPLES BELIEVED TO BE EDUCATIONALLY SOUND:

Where more definite and specific aims, such as are outlined in Chapter II are kept in mind by the teacher there is at least a strong possibility that more of such aims will be attained than in teaching situations where the chief emphasis is placed upon acquiring a particular body of general science subject-matter with little variation in student activity and little attempt at analysis of results. This is more probable since these aims for project teaching in general science were obtained by an analysis of the very activities that operate towards their attainment.[69] If there is a possibility that some such aims can be accomplished *in addition to* what is now being accomplished by text-recitation-laboratory work it would seem that project teaching in general science can be justified.

There is greater possibility for learning in general in project work in general science since such work more nearly approaches the educational ideal of keeping each student actively and profitably busy during every minute of class time. Even the individual laboratory work in the typical school occupies only two periods per week. Nearly one-half (at least 3/7) of the class time in the traditional school is taken up by recitation, lecture, or demonstration in which the possibility of a large part of the class being mentally inactive for considerable periods is great. In comparison with this the description of teacher's technique for carrying on project teaching[70] offers little opportunity for the mental inactivity of the students engaged in project work in general science.

Project teaching in general science is based upon sound psychological principles of learning [71] in that the student learns through the activity of his own nervous and muscular system rather than through the attempt to apply knowledge from without and in that the activity in which he engages furnishes its own motive. Therefore, project teaching should induce better

69 See pp. 313-319.
70 Pages 327-341.
71 Cf. Kilpatrick, "The Project Method,,, T. C. R., Sept. 1918, pp. 325 ff.

learning,—"growth,"—in general science teaching than teaching which does not utilize these principles.[72]

Project teaching in general science, because of increased interest in the school activity being carried on, seems to insure increased expenditure of effort on the part of students. Therefore, more prolonged, continuous, and intense effort seems to be put forth by students doing project work in general science than by students where school activity is carried on for the sake of externally applied motives.[73] (This conclusion assumes that such increased effort is desirable and worth while and that such increased effort will insure greater learning.)

There is a strong probability that greater initiative and independence will be developed in students doing project work in general science than is possible for students carrying on a type of work where almost every step is directed by the teacher.[74]

There is greater opportunity for the proper "socialization" of individual students in classes in general science in which project work is carried on than in classes in which students are handled *en masse* and their movements largely directed or inhibited by the teacher. In doing project work habits of co-operation may be built up, habits and ideals of tolerance and non-interference may be acquired, willingness to lend a hand to one needing help may be fostered, and interest in the work of one's fellows may be developed. Students may learn to work co-operatively and to do group work. Contrast this situation with class situations in which students are forbidden to work together or sometimes even to communicate with one another and where asking a question of a neighbor is cheating.[75]

There is a greater probability that students will learn to think for themselves and develop the "problem solving attitude" if they carry out general science projects of their own in which

72 Cf. Tables X-XVI.

73 Note the character of the projects included in the list in Chapter II, Cf. also Dewey, "Interest and Effort in Education," pp. 7, 9-11, 15, 23-24.

74 See the description of project work in Chapter II, the description of teacher's technique in Chapter II, section two, and the sample "direction sheets."

75 See Chapter II on the conduct of project work and the statement quoted from Mr. Buckles on page 250.

real problems, "cross-roads situations," are inherent than if they carry out dictated problems or memorize text-book materials.[76]

Because of the nature of project work in general science students engaged in such work very probably do a much wider range of reading than students who follow a general science text closely.[77]

Project teaching provides greater opportunity for meeting the needs of individuals with varying capacities than does traditional text-recitation-laboratory work. Greater opportunity and incentive is offered for the superior students to work to the limits of their capacity. Greater provision is also made for work that is within the limits of the capacities of students with relatively inferior ability.[78]

Project teaching in general science provides opportunity for more real and genuine teaching than the handling of students as masses or the hearing of recitations.[79]

Since the teacher is constantly called upon to meet new problems in helping students carry on new and varying projects there is greater possibility for teacher growth in project teaching in general science than is provided in the routine of text-recitation-laboratory teaching.[80] This greater possibility for teacher growth should in the long run make for better results in general science classes in which project teaching is carried on.

GENERAL CONCLUSIONS:

Project teaching in general science is justifiable and worth continuing and developing because (1) students doing project work do as well as, or better than, students engaged in text-recitation-laboratory work in securing general science informa-

76 Note the character of projects in the list found on pages 319-325. See also the description of the teacher's technique in Chapter II and the sample "direction sheets." Cf. also Dewey, "How We Think," pp. 40-41, 68-78.

77 Note the character of the projects in the list of projects, pp. 313-325, the description of the teacher's technique in Chapter II, and the sample "direction sheets."

78 Ibid.

79 Ibid.

80 Ibid.

tion and in securing acquaintance with and control of every-day physical environment, and (2) there are strong probabilities supported by apparently valid evidence that students doing project work in general science reach values more readily, or in a higher degree, than students doing text-recitation-laboratory work.

CHAPTER VI

EDUCATIONAL IMPLICATIONS THAT MAY BE DRAWN FROM THIS STUDY.

As a result of experience in carrying on project teaching in general science and as a result of the conclusions formed from the study presented here certain inferences concerning the relation of project teaching to education in general have been drawn. These inferences are presented as a contribution towards the solution of the larger and more important problem, the determination of the value of project teaching in the general field of education, which formed the background for this study and which can be only partly solved by any investigation carried on within the limits usually established for scientific studies in education.

These implications, or inferences, are not considered as proved. Many of them, however, seem highly probable and entirely possible in the light of the present investigation. Proof of their validity or invalidity is dependent upon further detailed exerimentation. Numerous studies and much experimentation will be necessary before the values and limitations of project teaching are entirely established. The present study is intended as an illustration of the possibility of placing the investigation of such problems upon a basis of concrete experimentation under actual class-room conditions. It is hoped that further investigation of the same nature will greatly extend the limited findings of this study.

The implications closely parallel the second group of conclusions presented in the preceding chapter. Some are in part repetitions of these conclusions. This seems unavoidable

since the implications have no value except as inferences drawn from the experimental work carried on in the more limited field. Any validity which they may have is derived from the close parallel between what is substantiated by experimental evidence and what may possibly be true in similar teaching situations.

The implications are as follows:

Since students in general science engaged in project work do as well in reaching commonly accepted aims for that subject as students engaged in text-recitation-laboratory work, it seems highly probable that this might also be true for junior and senior high school students in other "content subjects" such as physics, chemistry, biology, geography, social sciences, literature, home economics, etc. It may be doubtful if as good a case can be made for project teaching in those subjects which are largely skill subjects such as algebra and modern languages. Invetigations involving both types of subject-matter are needed. However, experience in manual arts tends to show that skills may be acquired by project teaching.

It seems quite probable that results similar to those secured in this study may be secured in other high school sciences since the procedure followed in most schools in these subjects is practically identical with that commonly followed in general science.

For subjects in which the teaching aims are discovered to be similar to those found to be common for general science, information and acquaintance with, and control of, environment, it seems probable that project teaching may secure results comparable to those secured in general science.

It seems possible that in subjects in which information is chiefly desired that as much information can be secured by students carrying on groups of projects or problems, organized within themselves but loosely organized as a whole, as by students following the usual text-books. In other words, the logical organization of courses as a whole with which many teachers are much concerned seems to make little difference so far as acquisition of information is concerned.

If project teaching in other subjects will lead to an analysis of possible student acivities within those subjects in order to determine more specific attainable objectives than now prevail

it is probable that some of these objectives can be attained *in addition to* what is now being accomplished.

There is a great possibility for improvement in teaching efficiency in any subject in which project teaching is found to be at all usable through the possibility of more nearly reaching the educational ideal of keeping every student actively and profitably employed during every minute of class time. Project teaching points in the direction of more work and less reciting for students.

Project teaching wherever it is found to be at all feasible should make possible the utilization of the sound psychological principle that individuals learn through their own activities and that learning is increased if such activities furnish their own motivation.

Project teaching should, regardless of the subject, lead to the expenditure of increased effort because of the increased interest in the type of activity involved.

Project teaching, wherever it is found to be practical, offers the possibility of developing greater initiative and independence than do teaching situations in which there is more teacher dictation.

Project teaching presents the opportunity for the proper "socialization" of individuals in any field in which it can be used. This opportunity is greater with project teaching because the working conditions are not so artificial as the working conditions where text-recitation procedure is used.

In general, project teaching should afford greater possibilities for developing ability to think in actual situations than the usual text-recitation procedure. This possibility presents a problem worthy of serious investigation in view of the widespread criticism of the memoriter methods common in schools everywhere.

Project teaching seems to guarantee a wider range of reading than is customary in most schools or in most subjects as they are now taught. This presents a decided opportunity in the fields of literature and social science.

There seems to be no question but that project teaching offers greater possibilities for providing for differences in the capa-

cities of individuals than any type of teaching situation now in use. The only question in this connection seems to be the question of the extent to which project teaching is practicable in subjects where individual differences must be taken into account.

Project teaching involving a technique similar to that described for project teaching in general science should provide for opportunity for more real and genuine teaching than text-recitation procedure. The development of such technique in other subjects is greatly needed and should precede attempts at evaluation of project teaching in other fields.

These implications seem to be theoretically sound as inferences drawn from a single limited investigation. They point to the need for further investigation of their applicability under real teaching conditions. Advance in education as a science, and advance in better methods of evaluation of what now seem to be intangible and immeasurable factors should make such investigation increasingly valuable and profitable.

The Local Water Supply System in General Science Instruction.

Earl R. Glenn, The Lincoln School of Teachers College, Columbia University.

During the summer of 1921, a group of general science teachers at Teachers College held a series of informal meetings for the purpose of developing units of general science instruction that would be based upon the water supply systems of the cities represented by the various teachers in the group. We decided to assemble samples of student work and arrange them in the form of an exhibit, which could be sent from school to school for classroom use. The first exhibit of this kind was based on the New York City system. In the meantime, Miss Bessey K. Gish of the East Technical High School of Cleveland, Ohio, and Miss Grace Musch of Muskogee, Oklahoma, prepared similar exhibits for the series.

One of the problems of science teaching is that of developing units of instruction based upon the particular needs of the

community. No textbook organization, as such, is a substitute for this type of instruction. On the other hand, it is extremely difficult, because of the necessary expenditure of time and money, for a teacher to make such an organization. The situation is further complicated by the fact that many teachers do not begin such work simply because they do not anticipate a long stay in any one community. If they do make a beginning, they carry their plans with them when they move.

It has seemed advisable to publish some of these preliminary outlines, in order that teachers may see how to begin the organization of local science material. It is probably true that they will be unsatisfactory in certain respects, and will require careful revision before further use in the class room. The formulation of such a preliminary outline is one of the most difficult aspects of the teaching process. With a preliminary plan as a guide, it is relatively easy to develop a satisfactory order for teaching the essentials of this unit of the course.

We hope that this series of outlines will stimulate other teachers to study their own communities, with the idea of making similar organizations of local material. After teaching several classes according to the preliminary outline, it will be possible for the teacher to formulate a plan which will be much more satisfactory from his own point of view.

In considering the study of the water system of a very large city like New York, the immensity of the system itself will necessarily call for a thorough study. It is difficult to see how justice can be done to the topic and the pupils if the teacher takes up this unit briefly and as a matter of form only. By this we mean that some teachers may teach the topic merely because it would be bad policy to leave it out. On the other hand, having decided not to leave it out, the teacher may not think it worth while to devote much time to the study of such a topic.

What is more important in the life of an individual than pure drinking water? If we stop to think of the part that pure water plays in the life of every person in the city, we realize that too much time can hardly be given to this unit. We attempt to justify the teaching of various scientific prin-

ciples by showing their relation to everyday life. How much motivation do we need to interest the pupil in the study of the water supply of his city? An inspirational talk by the teacher will suffice to arouse the pupil's interest in pure water. A field trip, preferably one which will show the general plan of the system, will interest the boy or girl by its magnitude and will spur him on to further investigation.

We are justified in taking time for this study, because of the various scientific principles involved. For instance, an opportunity is provided for the study of such principles as are related to water pressure, gravity, meters, siphons, screws (study of faucets), formation of springs, distillation, filtration, etc. In this way the facts and laws of science are discussed as part of a great scheme. The practical applications are easily seen. Their concrete relationship to everyday life is evident.

A series of lessons were outlined for five typical cities. These plans were published in the General Science Quarterly, from time to time, as follows:

CITY	TEACHER	SCHOOL	CITATION IN GENERAL SCIENCE QUARTERLY
Oakland, Cal.	Anna Lowrey	Joint Union High School, Kingsbury, California	6: 460-77, (March, 1922)
Cleveland, Ohio	Bessie K. Gish	East Technical High School	6: 551-67, (May, 1922)
Muskogee, Okla.	Grace Musch	West High School	7: 59-68, (Nov. 1922)
Cincinnati, Ohio	Anna H. Raitt	Bloom Junior High School	7: 127-35, (Jan. 1923)
New York, N. Y.	Earl R. Glenn	The Lincoln School of Teachers College	7: 274-97, (May, 1923)

All of these outlines, with accompanying samples of student work, are now available in the form of an illustrated booklet of seventy-six pages, entitled "Co-operative Work in the Organization of Local Material for General Science Instruction: The Water Supply System," which has been published recently by the Lincoln School of Teachers College.

The Evolution of Man's Communication

A Dramatized General Science Project, which integrates History and English with Science. Planned, written and presented by the Ninth Grade Science Class, Junior High School, Bloomsburg State Normal School, Bloomsburg, Pennsylvania. April 13, 1923.

CAST OF CHARACTERS.

Idol	**Pianist**
Egyptian Girl	**Assistant Announcer**
Speaker (Sign Language)	**Three Girl Scouts**
Spirit of Messengers	**Four Indians**
Samuel F. B. Morse	**Four to six Greek Women**
Ben (his friend)	**Greek Runner**
Alexander G. Bell	**Two Engineers**
Mose (his negro servant)	**Two Vikings**
Radio Announcer	**Postman**
Expert Electrical Engineer	**Telegraph Boy**
Abou Ben Hassam	**Introductory Speaker**

COSTUMES.

The use of special costumes in this play is optional, but a far better impression can be made if appropriate costumes are used. These costumes can be very easily obtained in almost every community.

INTRODUCTION.

This Introduction was written and given by one of the students.

The Ninth Grade Science Class has been studying Radio for some time, and in one of the class discussions the question concerning man's means of communication arose.

We know that man has progressed educationally, socially, and commercially, but we also know that this progress could never have been made had it not been for communication.

Since man is a social being, it seems only natural for him to wish to converse and come in contact with other men and other places. Our forefathers had no other means of learning about current events than by the stage-coach. But, today we pick up the "Morning Press" and read what is happening in the Valley of the Ruhr, what new discoveries are being made in King Tutankhamen's tomb, and what new political strife is taking place in Soviet Russia.

Communication was an important factor in the development of our country. America today might be a nation of thirteen colonies had it not been for communication.

We have dramatized the history of communication in a brief form, which we shall endeavor to present here this morning.

The planning of the play was done in class, and each part was developed by a group composed of from two to four members of the class. We believe that it has a great deal of educational value and hope it will give you a better idea of the history of communication.

PROLOGUE.

Stage Setting.—Idol, seated on platform about three feet high, at rear of stage. The platform should be draped and a piece of cardboard, on which are painted queer signs, hung on the front of it. The idol should wear a long, loose, flowing garment. The face of the idol may be painted with silver paint. When the curtain opens, the idol should have hands held over head and be perfectly motionless.

(Enter three girl scouts in hiking attire. They walk wearily as though wholly fatigued.)

3rd Scout.—Oh, I am so tired! I don't believe I can walk another step.

(2nd and 3rd Scouts sit down.)

1st Scout.—You two are always tired. You may sit down, but I'm not going to. (Starts to walk around.) By the way, have you heard about the latest discovery in King Tutankhamen's tomb?

2nd and 3rd.—No; what was it?

1st.—They found his heart and other organs of his body in bottles.

3rd.—Aren't these discoveries interesting?

2nd.—I am beginning to become interested in the past.

1st (walking around, she suddenly discovers idol).—Oh, look at that idol!

(All jump back excitedly when this discovery is made.)

2nd.—Isn't it peculiar?

(3rd Scout starts walking towards idol and 2nd Scout grabs her arm.)

2nd.—Oh, don't touch it!

3rd (pointing to signs).—L-l-look at those queer signs. I wonder what they mean?

2nd.—I wish the idol could talk. It could surely tell something about them.

1st.—In the story of Aladdin and his wonderful lamp, they waved a magic wand over the idol's head to make it talk. Let us try it.

2nd and 3rd.—All right.

2nd (waving wand over idol's head, says slowly).—Hokus pokus.

3rd.—Poky wokus pokus! (Any words may be used.)

(The idol moves. She brings hands down and holds small lamp or incense burner in front of her.)

Idol (speaks slowly in deep spiritual tones).—If you children are interested in how people used to communicate during the past, I will try to bring up the spirits of the past with this Aladdin's lamp. All put your hands at the base of the lamp, and we will see what happens.

(Scouts hesitate, but finally go over and kneel in front of idol, placing hands at base of lamp.)

(*Curtain*)

The scenes that follow show what they saw.

SCENE I.

PICTURE WRITING.

Stage Setting.—Indian wigwam on which Indian signs have been painted, on one side of the stage. A Cleopatra's Needle on opposite side. (Needle can be made of heavy cardboard. It should be about 7 feet by 8 inches by 8 inches, with a pointed top.) On every side are painted Egyptian letters. On the side toward the audience paint the following letters: *h* to represent our letter h, *C* = our s, *M* = m, *ʔ* = z, *n* = n.

After the curtain has been drawn, a girl dressed in Egyptian costume appears on stage and says:

I am an Egyptian. Many years ago I was less fortunate than you are today. I did not know of writing. We lived in small villages, with a chieftain to rule over us. Each year

we had to pay him so much grain for our water rent. To keep account of the grain we had paid him, we put marks on the inside of our huts. This resulted in picture writing. As our trade grew, this writing became more and more known, until we expressed everything we were talking about with pictures. (Walks over to Cleopatra's Needle; points to it.) Cleopatra's Needle, found in one of the Egyptian deserts, gives us a good idea of the old form of picture writing. First we see their letter "h." (Points to each as it is mentioned.) This represents tongs, and stands for our letter "s." This represents "m," and this "z." (Returns to front of stage.) These pictures were made on stone or some other material.

This is the form of writing which our American Indians used till recently. If you had passed through an Indian village a hundred years ago, you would have seen written on the wigwams love songs, songs to their gods, and sometimes the diary of the brave who lived within. (Goes over to wigwam.) On this wigwam is the diary of Chief Wingemund, a noted Delaware chief. Here we see the sun, his god, and here he is pictured coming home from battle victorious. (Points to different pictures while above is said. Returns to front of stage.) That this writing was very extensively used is proved by the fact that a group of American Indians sent a petition to the United States Congress written in this form, asking for more fishing rights on a small lake near Lake Superior.

(*Curtain*)

SCENE II.

Open stage. Speaker tells history of sign language:

Many years ago, at the earliest period of savage state, the necessity for communication developed certain signs, visible and vocal, which met the need felt at that time.

Speaking by gestures was in all probability first used, but vocal signs gradually crowded out bodily signs and gestures, and we see no more of them until we come to the Indian. (Two Indians are seen conversing by means of signs at this part of the story.) Although these Indians knew the use of speech, much of their conversation was by means of signs or gestures.

Nearly every important tribe had a sign language of its own; though many of them bore a close resemblance to each other. The Onondaga and Tuscarora tribes have dialects not only unlike each other, but are also distinguished from the others by strong dialectical differences. (One of the Indians makes alphabet.)

Sign language is also used today by mutes. It is almost their only means of communication.

There is also a great deal of sign language used in our everyday life, which we can readily note by watching those about us.

(*Curtain*)

SCENE III.

Stage Setting.—Open stage may be used. The speaker should be dressed to represent a spirit.

Enter Spirit of Messengers. She speaks slowly, in deep, hollow voice:

I am the Spirit of Messengers long departed, and also of the present age. As man has made use of different means of transportation, I also have used them. When man used the horse, I used it. As ships, bicycles, steam engines, and finally the aeroplane, come into the world to be of some use to man, I also made use of them.

The Indians at their lowest stage used human messengers to carry from one tribe to another word of danger, wars, victory or defeat.

The early Greeks conceived the idea that there should be messengers between the people and their gods. The winged god, Mercury, was the leading example of this kind of messenger among those primitive, yet cultured Greeks. After the battle of Marathon, a messenger again comes to the rescue, for Pheidippides, one of the fleetest runners of that time, carried tidings of great joy to the women and children at Athens. (At this time several Greek women enter from right side of stage. A runner enters from the left side with the news of the battle. He is almost exhausted. He staggers across the stage and delivers this message to the Greek women, "Rejoice, we conquered!" As soon as the message has been delivered,

he falls dead. Greek women exit, leaving runner.) This shows the spirit of the Greek people, as well as the necessity for human messengers in those days.

As we come down through the ages, we have many other kinds of messengers, one example being the couriers in Scotland, Turkey, England, and Persia, who ran special errands and carried special dispatches for the kings and sultans.

Today in America the most common messenger is the postman. (Boy dressed in postman's uniform walks across stage.) From the young folks, who are always particularly interested on St. Valentine's Day, to the older folks who look for business letters—all are especially fond of this messenger.

In early colonial days, a man in Boston wishing to get word to a man in New York, might be able to journey back and forth in about twenty days. Today we call a telegraph boy (Telegraph boy crosses stage, whistling as he goes) and send a message in a very few minutes for only a few cents, and get an answer in an equally short time.

Now, I have told you the story of man's communication by human messengers, from the earliest time to the present. Perhaps some more convenient and less expensive device than that of human messengers may yet be discovered, but that remains to be seen, as the world increases in wisdom, wealth, and civilization.

SCENE IV.

SMOKE SIGNALS.

Curtain opens with two Indians seated in front of wigwam. One Indian is whittling, while the other is engaged in deep thought. After whittling for a few seconds, the first Indian gets up and scans the horizon. Finally he sees a smoke signal from one of his tribe who is in danger.

1st Indian.—Ugh! (Nudges other Indian and points to the imaginary signal.) Eagle-eye, he in much danger.

2nd Indian.—Gotta make much smoke. Show him where tribe is. (Stoops down and lights a fire as a return signal to Eagle-eye. A little red phosphorus may be used for this purpose.) Ugh! heap much smoke. (Coughs.) That show him where come.

1st Indian (after watching the signal of Eagle-eye for a few minutes).—There, his fire go out! He see our smoke.

2nd Indian.—Sure, him good brave. Him Eagle-eye.

(*Curtain*)

SCENE V.

BEACON FIRES.

Place something in center of stage to represent a large rock. Chair, draped with gray covering will do.

The Vikings should be dressed in skins, if possible, and carry a shield (can be made of cardboard) and a large knife.

After the curtain is drawn the two Vikings enter. They are weary and footsore and are scarcely able to walk. Second Viking sits down on rock.

1st V.—After all these weary wanderings, we have not yet found the path to the village. (He is very much discouraged.)

2nd V.—Yes, I'd rather be on an iceberg than here in this forest.

1st V. (searching around).—If we only had flint and a bit of dry moss, we could manage a fire.

2nd V. (disgustedly).—If! It's always "if"!

1st V. (angrily).—Well, let's try to get out of this forest. What have we done that Thor should send his thunderbolts?

2nd V. (after pause).—Can it be that we are to be the sacrifices to appease our angry god's wrath? (Both shudder.)

1st V.—Well, don't give up. Let's watch for some sign. (Pause, during which they watch for sign. Suddenly beacon fires flare up in the distance. A strong flashlight may be used for this purpose. Light may be flashed on back of stage.)

1st V.—Oh! the Beacon Fires! We are not lost! (Exit.)

(*Curtain immediately*)

SCENE VI.

HELIOGRAPH.

Full Stage. Enter two engineers. Set tripod down and pretend to adjust it; look through glass.

1st Engineer.—Today the weather report is clear.

2nd Engineer.—Those tourists we saw this morning setting

out to see the Grand Canyon, may get lost, so we had better be on the lookout.

1st Engineer.—Yes, we can easily reach them, because the U. S. Signal Corps signalled with the mirrors 183 miles across this same canyon.

2nd Engineer.—When was that?

1st Engineer.—About 1863. (Works more on the tripod.) (Signals thrown on stage with strong flashlight.) They are signalling. (Pause.)

2nd Engineer.—I believe they are lost or in danger.

1st Engineer.—It says: "Lost. Come at once." (Signals.) (Exit.)

(*Curtain*)

SCENE VII.

THE TELEGRAPH.

Stage Setting.—Samuel F. B. Morse's workshop. Table in center. Two chairs at table. On the table are a telegraph set, numerous wires, and tools. *Costumes.*—Morse, ordinary working clothes; Ben, old straw hat, patched overalls, red handkerchief around neck. When curtain is drawn, Mr. Morse is seated at a table in his shop, working at the telegraph.

(Enter Ben, a poor, uneducated farmer, who is a friend of Morse.)

Ben.—Hello, Samuel! (Walks over to the table and starts picking around at different parts of the instrument. Morse watches him anxiously.) What for kind of a thing is that anyhow?

Morse.—Oh, that is a telegraph set.

Ben.—What is it for?

Morse.—To send messages by wire.

Morse.—To send messages by wire.

Ben (pointing to magnet).—What are those spools for?

Morse.—They are electro-magnets which operate the sounding lever.

Ben (looking at batteries).—What are those things there?

Morse.—Oh, they are voltaic cells, which furnish the current of electricity.

Ben (fingering the key).—What is that thing with the button on it for?

Morse.—That is the key which is used for breaking and closing the circuit.

Ben (pointing to wires).—And what are those wires for?

Morse.—They are to conduct the current, which carries the message, from one station to another.

Ben (laughing).—And do you really think that thing is going to work?

Morse.—Haven't you heard? This afternoon at 4.30, Mr. Vail, my assistant, is going to try to send a message from Baltimore to me here in Washington.

Ben.—How far is it to Baltimore?

Morse.—About 40 miles.

Ben (in surprise).—Forty miles! Great Scott, man, looks to me like you took a bigger bite than you can chew. Your upper story must be unfurnished! Surely can't send a message that distance with a thing like that. (Pause.) How long have you been working on this, anyhow?

Morse (after reflecting a moment).—Oh, about eleven years. (Pause.) I feel sure I shall get that message this afternoon.

Ben (consulting watch).—It is almost time now for him to send that message.

Morse (walking over and looking the instrument over again).—If this is successful, I shall devise a code of dots and dashes which can be used by the whole country.

(Both consult watches.)

Ben.—About one minute more, and it will be time.

(Morse sits down at the table, and suddenly the sounder starts to work. Morse receives the message and then sends an answer. Then he jumps up, highly elated, and slaps Ben on the back.)

Morse.—I have received the message. It reads, "What hath God wrought?"

Ben (gets up and says).—I will go out and spread the news. (Goes out.)

(*Curtain*)

SCENE VIII.

THE TELEPHONE.

Stage Setting.—Table and two chairs, with parts of telephone on table. *Costumes.*—Bell, plain suit of clothes; Negro, overalls, red bandana handkerchief around neck.

Note.—According to reliable sources, Bell was assisted by a friend in the invention of the telephone, but for dramatic purposes the group thought it better to have a negro servant assist him.

(Bell is working and negro servant is sleeping when curtain is drawn. After sleeping some time, negro wakens and yawns.)

Negro.—Oh, Massa Bell, it won't work. Why don't you leave it alone, an' go to bed an' sleep?

Bell.—Well, Moses, you don't understand. I can't leave this half done, when I think I could make communication so easy for my fellow-men.

Negro.—Well, Massa, I can't see what you started it fo', nohow.

Bell.—I didn't intend to make this invention when I began. I only wanted to make an instrument through which deaf people might hear. I don't pretend to know much about electricity, but Moses, I feel I shall succeed.

(After working for some time.)

Bell.—Now, go to the other end of the wire, in the basement, and we will try it once more.

Negro (yawning).—Just once more, Massa. (Exit negro.)

(Bell busies himself about the telephone.)

Bell.—Moses, are you there? (Listens a minute, then repeats) Moses, are you there? . . . Oh, I heard you! I heard you! Can it be true that I am on the third floor talking to you in the basement? Is it a success?

(Enter negro in great excitement.)

Negro.—I heard you, Massa. But how did you make that thing talk?

Bell.—Inside the transmitter (pointing), there is an elastic plate of sheet iron, which vibrates and sends out electrical impulses when I talk into the mouthpiece.

Negro (scratching head).—Yes, but what made it talk at the other end?

Bell.—The electric currents pass through a pair of electromagnets and act upon a plate of diaphragm, which agitates the air in the same way my voice does when I talk into the mouthpiece.

Negro.—Well, Massa, your talkin' thing worked after all.

Bell.—Don't call it my talking thing, call it the—(hesitating—tel-e-phone.

Negro (admiringly).—Massa, I believes you'se a great man.

(*Curtain*)

SCENE IX.

RADIO.

Scene.—Radio Broadcasting Station. Table and three chairs. Microphone on table. Wires. Piano or victrola. Announcer is seated at table when curtain is drawn.

Announcer (slowly and distinctly).—This is Station B. S. N. S., Bloomsburg, Pennsylvania. The weather report for the following week will be given in one minute. Stand by, please.

(Announcer adjusts microphone. Enter assistant, who shakes hand of announcer and then reads weather report.)

Assistant.—Washington, D. C., March 15, 1923, the weather report will be as follows:

Friday, March 16.—Six inches of snow in southern Florida, and warm rains in Greenland.

Saturday, March 17.—Warmer in Northwestern States and colder in Middle Atlantic States.

Sunday, March 18.—Heavy rainfall in eastern part of country, causing floods, and delaying the delivery of Sunday papers.

Monday, March 19.—Warm, with a rapid decrease of high water.

Tuesday, March 20.—Earthquake caused by the eruption of River Hill volcano.

Wednesday, March 21.—Eclipse of sun, visible at the North Pole only. Colder in Western America.

Thursday, March 22.—Cloudburst in upper Pennsylvania. The people in New York have been warned to watch for the flood.

(Exit assistant.)

Announcer.—This is Station B. S. N. S., Bloomsburg, Pennsylvania, broadcasting. Wave length 360 meters. Mr. Calvacanti, expert electrical engineer for the Bloomsburg Electric Company, will now give us a brief history of Radio. Stand by, one minute, please.

(Mr. Calvacanti enters and reads slowly and distinctiy this brief history).

Mr. Calvacanti.—Most of us are more interested in contemporary happenings than in comparative records. The entire development of radio is so recent that the full scope of its history is concerned with matters of our own generation. Here is a brief summary of progress in the development of radio:

In 1883 Thomas A. Edison discovered that an electric current can be made to pass through space, and in 1885 an English experimenter did the first electric signaling without wires.

In 1887 Professor Hertz, a German scientist, proved that electric waves pass through space with the speed of light.

In 1895 Marconi proved that electric waves can be transmitted through the earth, air or water by means of sparks producing high-frequency electrical oscillations, and in 1901 he sent the first wireless message across the Atlantic.

In 1902 the two-element thermionic valves detector for radio reception was invented, and in 1906 a high-frequency alternator system, having a range of twenty miles, was developed.

In 1911 a distance of 350 miles was covered by radio telephone in Germany.

In 1914 laws were passed by several great nations requiring vessels to carry wireless equipment and operators.

In 1918 both the radio telegraph and the radio telephone proved their tremendous worth in warfare.

Popular radio broadcasting began in 1921.

In 1922 the 20-kilowatt vacuum tube, the most powerful ever made, was announced, and in the same year Marconi also demonstrated his powerful radio searchlight.

1923. Radio is rapidly becoming more popular. Thousands of people are installing receiving sets.

(Exit Calvacanti.)

Announcer.—This is Station B. S. N. S., Bloomsburg, Pennsylvania. The next number on our program is a piano solo entitled, "Scottish," by Mademoiselle Guiomar Novaes. Stand by one minute, please.

(Victrola may be substituted for this part.)

Announcer.—B. S. N. S. now signing off. We will continue our program at 9.00 p. m., Arlington time. We wish all our patrons who are enjoying our programs would write to us. Address Principal Forrest Irwin, J. H. S., B. S. N. S., now signing off. Good night. John Smith, announcer.

(*Curtain*)

(Other parts may be added to this scene if desired.)

After Thoughts

GERALD S. CRAIG, Instructor of General Science,
Bloomsburg State Normal School, Pennsylvania.

(1) In our Junior High School an assembly period is alloted once each semester to each department. According to our most common practice, the students themselves decide the advisability of acceptance of such allotment. The problem of what to present is also left to the decision of the students. In this case, the Ninth Grade decided to accept the responsibility of a Science assembly program, after the Eighth Grade had refused. After considerable debate they agreed to take as their next assignment, an investigation of the history of communication and the possibility of its dramatization under the local conditions of stage, scenery, and time.

(2) Considerable zeal was indicated in this study. Books were brought from home and library, dealing with particular stages of communication. At the conclusion of the hour, the class decided that they would present the evolution of communication in its separate stages.

(3) The class divided itself according to individual interests and opportunities for the purpose of writing the play. Chairmen were selected by the members of the groups.

(4) Each group reported back to the class the particular scene with which they were entrusted. Frank criticism from the group followed. The criticisms were directed as to the historical and scientific accuracy, as well as the literary com-

position. Each chairman filed a list of properties involved and a copy of the scene with the instructor. Property officers were appointed by the chairmen. This particular class period rated 167 on the tentative Herring Project Scale.

(5) The class selected the cast. As a whole members were selected for a particular part because they had conceived and written the scene.

(6) Stage managers and property officers were either selected or elected. Scientific experimenters were appointed, who investigated:

a. The advisability of the use of tableau salts according to chemical recipes found by the students in Popular Science Monthly.

b. The wiring of a miniature electric light for the crystal.

c. The use of red phosphorus for smoke signals.

d. The history and construction of the telegraph, telephone, and radio.

e. Inside construction of broadcasting stations.

(7) Criticisms were received at all stages until final presentation. Constructive criticism was given, petty criticism frowned upon,—the class in a body, by vote, making all important decisions. The instructor was given a voice as a member of the group. Individual students presided at such times. Frequently the instructor's opinion was sought. There was little left to criticize at the close of the group's action.

(8) The stage was comparatively dark during the early scenes. Light was added from scene to scene, as symbolic of man's progress from darkness to light.

(9) Students agreed that suggestions of modifications should not be received after the last rehearsal, and that it would be wise to have military discipline during and immediately preceding the presentation of the play, with the teacher as the autocrat. They abided by this decision, each stepping to the post agreed upon.

(10) A little over two weeks was consumed from initial class period until presentation. Only two or three class periods were used other than the regular science periods.

The class is deeply obligated to the co-operation and assistance of student teachers, Ira C. Markley and Andrew B. Lawson.

Teaching General Science by the Project Method

C. W. Garman, Davenport, Iowa.

General Science is taught in the Intermediate or Junior High Schools of Davenport, Iowa, by the Project Method. The project method has been tried in the presentation of various subjects, with varying degrees of success, but the subject of general science has proven to be especially well adapted for the use of this method of teaching. To begin with, the field which is covered by this subject is so broad that there is a world of valuable material from which the teachers and pupils have found subjects that appealed directly to the fundamental interests of all the groups of pupils from various walks of life.

We have "worked over" a world of subjects, and at last we have settled down by common consent to a group of projects, the number of which has been limited arbitrarily by the number of class hours at our disposal. For example, our eighth grade spends two hours per week for forty weeks in the science laboratory. Thus we find that we have eighty hours in which to "work out" as many subjects. Each subject is made a complete unit of information. We term each subject a "project," and the pupils and teachers attack the project from every angle and use any and every means to develop the project, both in and out of school. Let us glance very hastily at a half-dozen of these eighty projects which are handled by the eighth grade.

Illuminating Gas. A group of students sets up the necessary apparatus and actually make some illuminating gas in the laboratory. They also secure the most common by-products, such as tar, creosote and coke. Another group visits the city gas plant the previous evening and makes a report to the class on the practical operation of a city gas plant. Other groups or individuals make various reports to the class from library readings, so as to inform the class how other cities secure "natural gas," or make "water gas."

ICE. One group of pupils actually makes ice in the laboratory. Another group reports on cooling devices and cold storage methods which they have learned about in their library readings.

WATER. One group prepares a few microscope slides which expose to view some of the common organisms found in impure water. Another group demonstrates how some of the common impurities can be removed by the "alum treatment" and filtration through sand. Another group clarifies some water by the "chlorine treatment." Another group reports on the method of operation used in the city water works.

FOOD TESTS. One group tests and classifies the starchy foods. Another group handles the protein tests. Another handles the sugar tests. Another handles the acid tests. Another the fatty foods, etc. Then a general discussion follows in regard to proper rations for people in various occupations.

CLOTHING. Groups test various kinds of cloth for the presence of wool, cotton, silk, linen, etc. Then general discussion follows in regard to clothing suitable for different seasons and climates.

BUILDING MATERIALS. Pupils have collected a variety of materials and these are used for general discussion pertaining to their qualities and uses. Besides concrete, steel, brick, etc., they have collected about fifty kinds of lumber, and they have learned why different kinds of lumber are used for various purposes. For example, the white oaks for floors, and red oaks for doors, windows and casings. Walnut and mahogany for furniture in home, while maple is used in schools, etc. The project method surely makes the teacher work, but he has the supreme satisfaction of seeing some good results obtained. It is a splendid method for inciting individuality in school work, no matter whether done in the class room, or the home, or the factory, or field.

On the "Path of Gold" to 'Frisco in 1923

THE "Forty-niners" dreamed of a path of gold to 'Frisco—a path that was to make them wealthy beyond anything thought of back East. Some of them made the grade, but only a few. Here and there you will find a man still living who made the long, slow, terribly hard trek west, searching for gold. Does he compare his own progress across country with the newest developments in transportation?

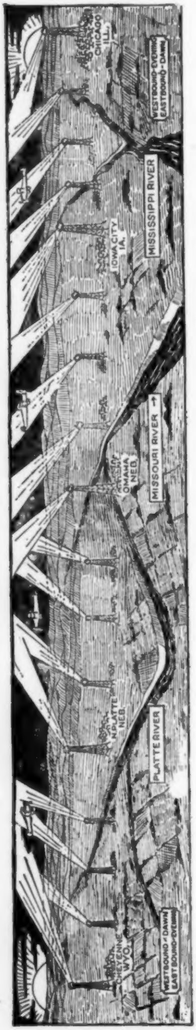
Even Darius Green and his Flying Machine hadn't been heard of then, and yet, all in the space of a lifetime, we have bird-men flying from New York to San Francisco in twenty-eight hours, over a path of gold.

And there is just one element that makes such a thing possible—*light.* Without light of almost unthinkable intensity, night flying would be limited to very short flights, and a coast-to-coast twenty-eight hour service would be impossible.

But with the need came the development of powerful searchlights and "land lighthouses" to guide the mail planes.

Some of our readers are living in the zone covered by the "Path of Gold" which lights the New York-San Francisco air mail, and they realize the marvelousness of these land lighthouses, which might be called "Sky Pilots." But perhaps the rest of us do not

apprpeciate the power and extent of these great guiding beams. Just think of a beacon light of 325,000,000 beam candle-power, such as will be at the eastern end of the darkness zone, in the cross-country route, at Chicago. At Cheyenne.



Wyoming, 800 miles away, another similar one will mark the end of the dark zone. Between them will be three others of the same size at points where permanent landing-fields of the night mail are laid out, Iowa City, Omaha, and North Platte Then, at intervals of 25 miles, there will be beacons of 12,300,000 candle-power, marking emergency landing-fields, and the combined strength of all these powerful rays, if united in one great cone of light, would be equivalent to the light of nearly two billion candles. At three-mile intervals along the route there are smaller lights flashing their guiding rays to the aviator. These will be equipped with sun valves, which will turn on the lights at dusk and off at sunrise. They will also be equipped with a wireless device which will signal if the lights go out from any cause, but the greatest reliance will, of course, be placed on the visible, tangible lights.

The fields themselves will be outlined in light; chimneys, poles, cars and high buildings in the neighborhood will be lighted, and other objects will be made to stand out so that the flyer can gauge the landing levels. The landing-field in which he puts his plane upon the ground, will be clearly marked by light, while the newest illuminated weather cone will show the aviator the wind direction on the field. The aeroplanes themselves are equipped with standard lighting and signal systems. —*Edison Sales Builder.*

Prone-Pressure Resuscitation [1]

Recorded history is replete with examples of man's willingness to make sacrifices for a friend, even to that of life itself, and there are few of us indeed who cannot accept this as a guiding principle, or at least as a lofty ideal. Unfortunately, an equally small number of us accept the principle of being prepared to save a life without risking anything at all in the attempt, to the extent of learning how the thing may be done. And yet the opportunities to save *without* sacrifice present themselves far more frequently than those to save *by* sacrifice. Almost every day a number of persons are drowned, or are overcome by gas, smoke or fumes, or are made unconscious by electric shocks. Some of them are beyond help when discovered; some die because immediate and proper assistance is not given; while others are restored to life and health by the fortunate circumstance that someone was on the scene who was able to render timely first-aid in the form of prone-pressure resuscitation.

When emergencies arise, such as fires, explosions, drownings, and other similar disasters or misfortunes, representativss of our civic bodies, particularly of the police and fire departments, are usually at hand or are among the first to arrive on the scene. As a rule, these men are highly skilled in handling the situations that ordinarily develop under such circumstances, but records of various organizations show that a majority of their members are woefully deficient in the training that is needed for the resuscitation of unconscious persons. Many of these men still follow the practice of tapping the soles of the feet, or producing by other means a counter-shock to restore consciousness. Failing in this, a physician is called, and pending his arrival nothing is done except to keep the crowd back. Even well-intentioned persons, properly trained in prone-pressure resuscitation, are often prevented from rendering assist-

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1 From "The Travelers Standard," by courtesy of The Travelers Insurance Company.

ance. When the physician arrives, the unconscious person is probably beyond help and is pronounced dead; or else his critical condition is noted, an ambulance is called, and the patient is removed to a hospital. The tragic part is the fact that the delay thus caused often robs the victim of his sole chance for recovery.

An actual case in point is that of a man in one of our Eastern states, who was pulled out of a river in an unconscious condition. A crowd quickly gathered, and a police officer was doing his best to maintain order, when a schoolboy edged in and announced that he was a Boy Scout and knew how to apply the prone-pressure method to restore respiration. He was gruffly ordered away by the policeman, just at the moment he caught sight of the unconscious man and recognized him as his own father. His insistence, supported by the sympathetic attitude of the bystanders, overcame the policeman's objections, and the boy set to work. He was interrupted by the arrival of the ambulance, which had been summoned in the meantime. The attending physician declared the man to be dead, and ordered the body removed to the hospital. The schoolboy, knowing that this was not the time to give up, and having the courage of his convictions, insisted upon going with his father and working on him in the ambulance. This was permitted, more in a spirit of tolerance than in the hope that good would result; yet the boy succeeded in restoring his father to consciousness before the ambulance reached the hospital,—bringing him back, in fact, from the very shadow of death.[2]

There are hundreds of cases every year, in which the attitude of our civic representatives varies only in detail from this one. As a rule, these men are not trained in the prone-pressure method of resuscitation, and hence they are personally unable to render immediate assistance. Their regulations instruct them to seek medical or hospital aid at once, and by inference the aid of laymen is not permissible, and it certainly is not solicited. There are many instances where volunteer prone-pressure workers have been stopped upon the arrival of a

2 This was a real occurrence, and is fully authenticated.

policeman or physician,—possibly because the very simplicity of the method made it appear valueless. No matter what the underlying reason, our civic authorities know altogether too little about the value and benefits of prone-pressure resuscitation.

This is not written in a spirit of adverse criticism, but rather in the hope that it may arouse interest to the point of bringing constructive action. It is a matter about which there can be little argument, because there are too many authentic cases of men being alive and at work today, who would surely be numbered among the dead, save for the fact that somebody was able to render prone-pressure aid at the critical time. The fact that firemen and policemen are usually among the first to be present, or to be notified of a case requiring assistance, emphasizes the need of instruction in prone-pressure resuscitation as part of their regular training.

The following essentials relating to the method of performing artificial respiration should be borne in mind. First and foremost, it is absolutely imperative for the work of resuscitation to begin *immediately* after a person has been freed from an electric conductor, taken out of the water, or removed from any other place where he has been overcome. Send somebody else for a physician at once, but do not wait for him to arrive. Rip or cut away any tight clothing (such as a collar, belt or corset) about the neck, chest or waist, as quickly as possible, *but remember that every moment of delay is dangerous.* Then lay the victim face downward, with the right arm fully extended forward, parallel with the body, and the left arm bent at the elbow to form a pillow on which the head should be placed with the face to one side. Quickly remove any object (such as tobacco, gum, candy, or false teeth) that may be in the patient's mouth, and draw his or her tongue forward, so that it will not obstruct the free passage of air.

The rescuer should now kneel astride the victim below the waist, facing the head, and place the palms of his hands on the victim's sides and small of the back, just above the hips and touching the lower ribs. (The position and action are well shown in the accompanying engravings.) With arms held

straight, the rescuer should then swing slowly forward, so that his weight will be brought to bear *gradually* and fully (but never with violence) upon the patient, and should then swing back to the starting position. The entire cycle of operations should be completed in four or five seconds. This corresponds to twelve to fifteen cycles per minute, which is about the natural rate of breathing. Do not expect immediate results from this treatment, but keep up the work without interruption for at least three hours, unless natural respiration starts before that time.

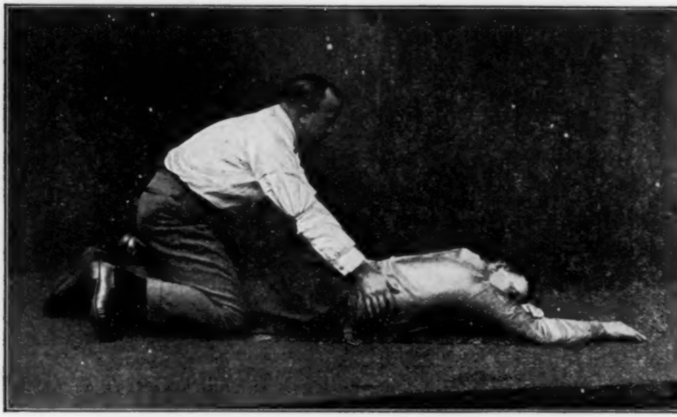


Fig. 1. Performing artificial respiration. First position, no pressure being applied.

During all this time, see that the patient has plenty of fresh air, and that he is kept warm. If he has been overcome by drowning, his clothing will be wet and his body will be seriously chilled. Blankets and hot-water bottles are therefore needed in such a case, *but the man who is trying to restore breathing must not undertake to provide these things.* He must attend faithfully and continually to the treatment as described above, and let somebody else look after the blankets and the hot water. If the rescuer is alone, he must confine his attention to the respiratory movements, because these are of *primary importance,* and everything else is secondary. The treatment for the

restoration of breathing must begin *immediately* and be carried along *continuously,* whether a physician has been sent for or not, and whether the patient can be kept warm or not. Doctors and hot-water bottles are of no use to a man who has been allowed to die in consequence of delay in beginning the respiratory movements, or through suspension of these movements when they have once been started.

The position shown in the engravings for the man who is trying to restore the breathing has been determined, by extensive experience, to be the best that can be suggested. If two

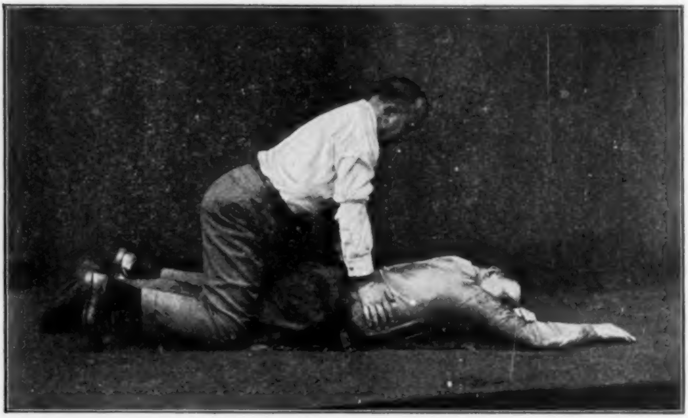


Fig. 2. Performing artificial respiration. Second position, applying pressure.

or more men are available, who are equally skilled in this work, it is advisable to have them relieve one another at reasonable intervals; but every man who undertakes to give treatment of this kind should be prepared to find himself alone with the victim at the time of the emergency, and be ready to do all the labor of the resuscitation work without assistance. This means that he should give careful attention to the position that experience has shown to be least productive of fatigue, because three hours of continuous, conscientious and effective effort of this kind, will try him severely.

In this connection we want to call attention particularly to two points. First, the ideal action consists in *rocking backward and forward,* by flexing the knees, hips and shoulders, while keeping the arms straight. This throws the operator's weight alternately on and off the patient, without producing as much fatigue as is necessarily caused by flexing the arm muscles or by raising or lowering the body by means of the leg muscles. Second, it is advisable to hold the thumbs nearly parallel to the fingers instead of allowing them to project outward at right angles to the fingers, or nearly so. This may appear to be a small detail, hardly worth mentioning; but in a long session it will be found well worthy of attention, because cramps are likely to develop in the thumb muscles after a time, unless the advice here given is heeded. In a treatment lasting for an hour or two, the operator will naturally be forced to change his position and his motions somewhat, to relieve his own fatigue; but he should know, at the outset, what position and what motions are least productive of fatigue.

When natural breathing has been restored, the patient should be placed on a stretcher and taken to his home or to a hospital, where he should be kept in a warm bed for some time. Meanwhile, he should be carefully watched, and if the natural beathing stops, artificial respiration must be used again. Do not put any liquid into the patient's mouth until consciousness is completely restored.

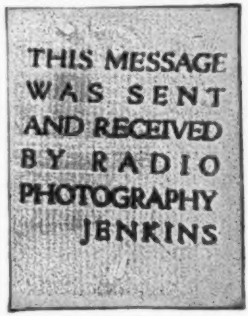
No Magic Gold Finder

There is no instrument that you can use to discover gold supposed to have been buried in an iron pot or steel safety box, writes the Director of the United States Geological Survey to a correspondent. Iron ore beds extending over large areas have been prospected for with success by means of the so-called "dip needle," but this instrument would not indicate the presence of a single pot or vessel in a particular spot. Neither is there any instrument that would indicate the presence of gold or silver or their ores. Iron attracts the "needle," but gold and silver, however attractive to man, are not magnetic.

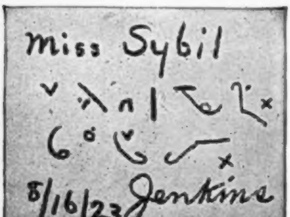
The Transmission of Chinese, Shorthand, and Photographs by Radio.

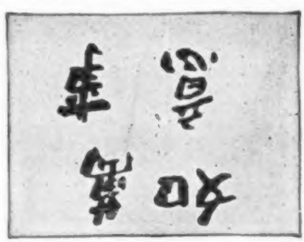
By L. C. Porter.

During the past two or three years, Mr. C. Francis Jenkins, of Washington, D. C., has been developing apparatus for the transmission of photographs by radio. This work has reached the point where very good still pictures are being successfully transmitted, and fair motion pictures have been also sent by the same means. Special Mazda lamps are essential to Mr. Jenkins' equipment. In describing this work, Mr. Jenkins writes as follows:



"I am enclosing some specimens of (1) a typed message; (2) a shorthand message; and (3) an example of a radioed message from one Chinaman to another, the first time in history, for, as you probably know, when the Chinaman or Jap uses the radio or the wire telegraph, he must have an English-speaking translator who will change into English the ideas represented by the Chinese characters, then reduce this English to dot-and-dash code, and then at the receiving end this code must be changed back into English, and then translated into the ideographs of the Chinese or Japanese. My process enables the Chinese or the Japanese to send ideograph messages to his countrymen without inviting in the foreigner to translate it out of and back into the characters of his own country."





The possibilities of this work almost stagger the imagination. The time is not far distant when

we shall see in our own living-rooms motion pictures of current events as they are taking place. It is not only possible, but probable that we shall show in our schools and colleges great educational motion pictures broadcasted by radio. Instead of the country student struggling along under incompetent teachers, he, as well as his more fortunate fellow in the great city, will have the inspiration gained from listening to lectures given in person by the greatest authorities in the world.

Photograph transmitted by Radio.

It is misunderstanding that causes most of the difficulty between individuals and between nations. Communication, more than anything else, assists in doing away with such misunderstanding. When we are broadcasting pictures, as well as the human voice, and sending them simultaneously, a tremendous advance will be made towards the realization of universal peace on earth and good will toward men.

—*Edison Sales Builder.*

The New Books

Ruch-Popenoe General Science Test—Giles M. Ruch and H. F. Popenoe—World Book Company.

This is an accomplishment test in general science for use in the seventh, eighth or ninth grade. There are two forms, A and B, of equal difficulty. Each form has two parts. Part one lists fifty incomplete sentences. Pupils are to select from a list of seven words given, the proper one to complete the sentence. Part two has twenty diagrams. Two or three incomplete sentences refer to the diagram. Pupils fill in the blank spaces. A seven-page manual of directions, keys for forms A and B, class record blank and blank form for percentile graph may be secured with the test papers. Sample test questions will be found in General Science Quarterly, Vol. 7, pp. 191-193, March, 1923.

Everyday Mysteries—Charles G. Abbott—198 pages—15 plates—$2.00. The Macmillan Company.

This is one of the series of books, "The Young People's Shelf of Science," edited by Edwin C. Slosson. The sub-title, "Secrets of Science in the Home," indicates that we are to learn of the mysteries of home science. A better idea of the contents of the book is given by a few of the chapter titles: the plumber's surprise, something

about soap, fixing the clock, door bells, the home-made bicycle, blueberries, pots and pans, saving half the coal pile, rags and velvet gowns, bread and cheese. The science secrets of these everyday things are told in a most fascinating manner. The book is an excellent one for supplementary reading in general science classes.

Pierre Curie—Marie Curie—244 pages—8 plates—$2.25—The Macmillan Company.

The glimpse into the life and work of Pierre and Marie Curie afforded by this book will be welcomed by science teachers everywhere. There is an introduction by Mrs. W. B. Meloney, who was instrumental in bringing Madame Curie to America and in persuading her to write this book. Madame Curie writes at length of the life of her husband and gives one chapter to her own autobiography, and a final chapter to her trip to America.

General Science Syllabus—J. C. Leovenguth—63 pages—World Book Company.

As the title suggests, this is not a text but an outline for any teacher to follow. The outline follows, in the main, the order of topics in Fall's Science for Beginners, but page references are given to nine general science texts. If a sufficient number of the different texts can be provided, so that pupils can have access to them, and they will work up a topic by using several sources, this ought to furnish a means to some very good teaching.

Laboratory Chemistry for Girls—Agnes F. Jaques—244 pages—D. C. Heath & Company.

This book is more than a laboratory manual. It outlines a full course in chemistry. It contains some text material, but gives references to many different books for the main treatment of subject matter. In addition to the experiments found in the general course, there is much valuable material and many experiments on foods and physiological chemistry.

Laboratory Experiments in Chemistry—N. Henry Black—172 pages—100 illustrations—The Macmillan Company.

This is a loose-leaf manual to accompany Black and Conant's "Practical Chemistry." It contains directions for performing eighty experiments, including those required for entrance to college. The directions are printed on left-hand pages, leaving the right-hand pages blank for pupils' notes. It has small pages, about the size of the textbook pages. It is needless to say this is prepared with the usual care which is characteristic of this author and teacher.

Makers of Science—Ivor B. Hart—320 pages—120 illustrations—$2.75—Oxford University Press, American Branch, New York.

This is a most valuable book for the science and the mathematics teacher, also for pupil reference. It gives a clear account in simple language of the progress of physical science and mathematics, century by century, showing that truth has repeatedly replaced fallacy. The chapters are: Aristotle; The School of Alexandria; Roger Bacon; Copernicus; John Kepler; Gilbert, the Father of Magnetic Philosophy; Galileo, the Founder of Experimental Science; Descarte and Coordinate Geometry; Sir Isaac Newton; Robert Boyle; Ampere; Sir Humphrey Davy; Ohm; Michael Faraday; Lord Kelvin; Science of Today and Tomorrow. In this last chapter you will find a brief but excellent explanation of the new Einstein theories.

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